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Carpools, Vanpools, and High Occupancy Preference Lanes Cost Effectiveness and Feasibility

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CARPOOLS, VANPOOLS, AND HIGH OCCUPANCY PREFERENCE LANES: COST EFFECTIVENESS AND FEASIBILITY

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16. Abstracts
This report looks at the reductions in vehicle miles traveled (VMT) and air pollution that can be accomplished with voluntary transportation control measures. The measures studied are carpool/vanpool programs and preferential highway lanes for buses and other high occupancy vehicles (HOVL). The report examined transportation control programs in four major metropolitan areas to analyze what factors affect the programs' effectiveness. Based on empirical data and use of a computer model, the report predicts that carpools, vanpools, and HOLV's may reduce car use 2-3% and save travelers millions of dollars. The costs of these programs are generally small compared to their benefits, except where new highway lanes are built for use as potential lanes. However, the study concludes that major reductions in air pollution may not be accomplished unless mandatory traffic controls are also used. The study also describes how people travel to work in 124 major metropolitan areas and includes case studies of carpool, vanpool and HOVL programs in use in both urban and less-densely populated areas.

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EXECUTIVE SUMMARY

Outline:

1. Purpose of Study
2. Methodology and Study Plan
3. Findings
4. Summary

1. Purpose of Study

Transportation Control Plan (TCP) measures have been introduced as a regulatory mechanism to complement the Federal New Motor Vechicle Program and the Federal New Source Performance Standards Program in order to ensure attainment of the national Ambient Air Quality Standards AQCR's that were in violation of the Standards. As envisioned in the 1970 Clean Air Act, the affected locality in consort with its respective State develops a TCP. This TCP is then presented by the State to the Federal EPA as part of its required SIP. The Federal EPA can then concur on the adequacy of the SIP or it can require the State to revise the SIP. In the event that the State does not submit an adequate SIP or does not revise it within a reasonably prescribed time, the Federal EPA is empowered to promulgate its own SIP, and in many cases its own TCP for the non-attainment localties. At present there are twenty-nine AQCR's that require TCP measures to comply with the NAAQS for Oxidant. These AQCR's are primarily in the densely populated, urban centers of the nation.

Common to many of the TCP measures is the desire to reduce the dependence on low occupancy Light Duty Vehicles (LDV), and to promote, simultaneously, efficiency savings in energy and general economies for the vehicle-owning public. In many of the 29 non-attainment urban areas, where the existing auto stock is composed of vehicles with different control technologies (newer cars meet more stringent standards), the Federal New Motor Vehicle Program is insufficient by itself to attain the ambient air quality standards. For many of these non-attainment areas, such as the South Coast Air Basin in southern California, NAAQS compliance could not be attained in the immediate future even if the entire auto fleet met the most stringent statutory standard,90% emission reductions from 1970 cars. This is due to increase in both Vehicle Miles Traveled (VMT)/capita and population. For this heavily polluted air basin, and in similar non-attainment areas, regulation of auto use is an essential part of a total air quality management strategy.

This report was prepared with input from several people. William Crowell, Arnold Bloch, and Granville Sewell were mainly responsible for data collection on Costs and Case Study experiences. Gregory Ingram provided expertise both in modeling which calculated reductions in auto use from Carpools, and Improved Transit in the four selected SMSA's (L.A., Boston, Chicago, Washington, D. C.) and in the conceptualization of the total effort. E. J. Bentz, Jr., Project Director, Sandra Bodmer-Turner, and William P. White III were responsible for the overall conceptualization, direction, review and final integration of the report.

Numerous colleagues also assisted in the preparation of this volume. Toby Clark, U. S. Council on Environmental Quality, was of crucial assistance in project conceptualization; Jim Davis, Center for Regional Technology, Polytechnic Institute of New York, was responsible for computer analysis of New Jersey carpool programs, Eugene Kroch and Donald Walls, Department of Economics, Harvard University, were responsible for assistance in the effectiveness modeling efforts; John Attanucci, MASSPOOL, provided crucial information on data on the MASSPOOL carpool program; Fred Hart of Fred Hart Associates and Ruben Brown of the Council on the Environment of New York provided assistance in reviewing the data preparation efforts; Louise Bryant, and Cindy Kanewischer provided unflagging professional support services.

Voluntary carpool/vanpool programs and preferential lanes are two transportation control policies that have received wide support from environmentalists, energy conservation groups, and the public at large. Because of this public interest in these control policies it was thought prudent to understand, and measure in detail, the costs, effectiveness, and feasibility of these control programs in reducing HC auto related emissions.

2. Methodology and Study Plan

Two methodologies were employed by the study team: detailed case study analysis with extensive on-site visits provided cost and feasibility information; the use of TASSIM, and TASSIM-type transportation-airshed model simulations for four case cities provided estimates of reductions in auto use and auto HC emissions. To understand how various transportation control programs will work in a particular city, it is ultimately necessary to analyze the programs for that specific city, yet much can be learned about the range of effects of control programs by analyzing their impacts in several cities with widely varying characteristics. For this reason the cities chosen were: Los Angeles, Boston, Chicago, and Washington, D. C.

(A) Case Study Analysis/On-Site Visits: a detailed study of existing carpool/vanpool, and High Occupancy Vehicle Lanes (HVOL) programs was conducted in order to identify key factors that determine program success. Particular emphasis was placed upon cost variables, benefits, and feasibility of program implementation (marketability criteria). From these empirical data, a working hypothesis was constructed relating commuter response to carpool promotion/matching programs to critical employment, transportation and location variables (e.g., firm location and size, availability/quality of transit, homogeneity of work force, work force schedules. . .). We also placed great emphasis on identifying key institutional variables that seem to affect program success, such as level of governmental participation, program organizational structure and external benefits to employers. Equipped with this working hypothesis, on-site visits were conducted in the four case cities to obtain first-hand cost-effectiveness and feasibility estimates of actual program implementation. Throughout, emphasis was placed on acquiring a set of reliable, authoritative, and well documented set of empirical factors which determine the cost, effectiveness, and feasibility of program implementation.

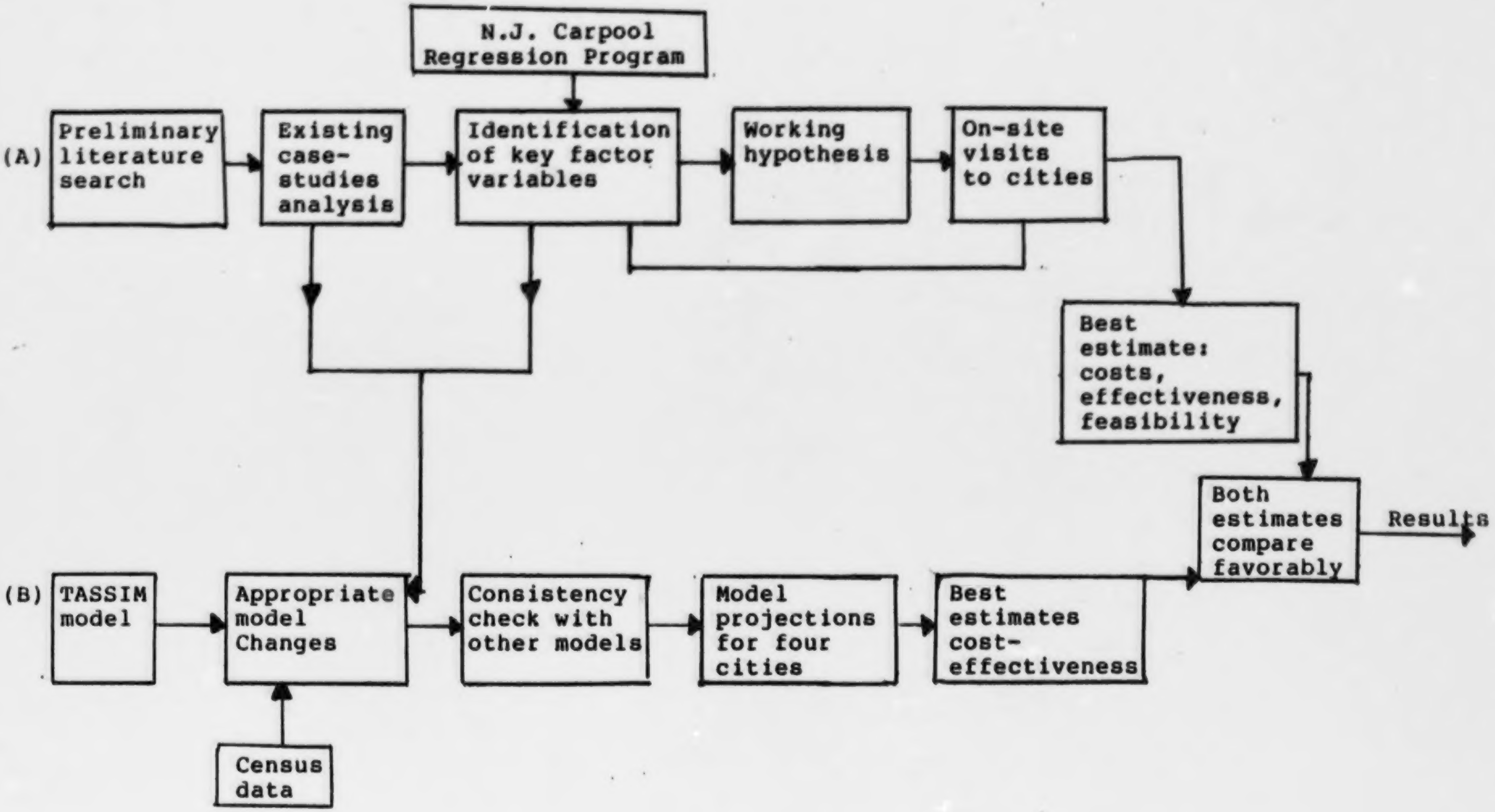
TABLE 1

PERCENT CHANGE IN PERSONS PER AUTO (PPA) FOR VARIOUS CARPOOL RESPONSES

Item	Boston	Los Angeles	Chicago	Washington
		Basic Data		
Average PPA	1.40	1.39	1.4	1.4
Worktrip PPA	1.21	1.11	1.19	1.21
Worktrip Share of VMT	.38	.35	.40	.38
Elasticity of Total PPA with Respect to Worktrip PPA	.368	.339	.388	.368
Percent Increase in Worktrip PPA for Various Carpool Responses				
Pessimistic	0.363	0.583	0.599	0.358
Optimistic - 250	6.03	5.72	6.74	5.32
Optimistic - 100	8.10	7.98	8.92	7.97
Percent Increase in Overall PPA for Various Carpool Responses				
Pessimistic	0.138	0.203	0.239	0.136
Optimistic - 250	2.21	1.93	2.59	1.96
Optimistic - 100	2.93	2.66	3.39	2.89

Source: See text for derivation

(B) Computer Modeling Simulations: Equipped with the empirical data and information from (A) and supplementary census data , the TASSIM model was modified. Appropriate model modifications were made to enable calculations to be performed for each of the four cities. Average auto occupancy shifts were derived for each of four cities for different carpool response scenarios. Supporting model consistency checks were made with different models using different modeling techniques to test the sensitivity and reasonableness of TASSIM's assumptions. These checks confirmed our model's results. Emission reductions were then computed through the model, using the already calculated VMT reductions calculated from changes in auto occupancy rates.


N.J. Carpool Regression Program
(A)
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Identification of key factor variables
Working hypothesis
On-site visits to cities
Best estimate: costs, effectiveness, feasibility
Both estimates compare favorably
Results
(B)
TASSIM model
Appropriate model Changes
Census data
Consistency check with other models
Model projections for four cities
Best estimates cost-effectiveness

STUDY PLAN

3. Findings

(A) Voluntary Ride-Sharing Programs

Our findings direct most attention to employer-based voluntary carpool matching programs. Our case study experiences show that these programs have the highest degree of potential, especially in areas poorly or inadequately serviced by transit such as most suburban areas. In dense urban areas, where CBD-destination commuter work trips are well serviced by transit, carpool programs should not be strenuously promoted since they draw rider off transit.

As discussed in detail in the case studies, direct governmental costs for operating regional ride-sharing programs can range from about $1 million (Los Angeles) to about $150,000 (Washington, D. C.). If the costs of the matching procedures are borne by employers, as they often prefer, the governmental costs can be drastically reduced while an individual firm's costs are relatively minimal. Costs associated with vanpool programs are also relatively small with fares set to cover all but the firm's usually moderate administrative costs.

Employer based voluntary carpool matching programs have evolved mainly from mutual economic benefits to employees and employers. The principal beneficiaries of these ride-sharing programs are the travelers themselves, especially those switching to carpools or vanpools after formerly traveling long distances in single passenger cars. The travel cost savings realized by only a modest number of new carpools can easily be in the millions of dollars, thereby making even inefficient matching efforts cost-effective. Employers have also realized substantial savings from the reduced demand for expanded parking facilities, as well as the additional advantage of securing more uniformity in scheduling worker arrivals/departures. Our case study experiences further indicate that employers tend not to seek subsidies for the promotion of carpools (or vanpools) since they usually view submission of personnel data to outside agencies suspiciously and regard the costs of internal management as inconsequential.

Since employer-based ride-sharing programs depend for their implementation on the voluntary efforts of commuters seeking marginal savings in travel expenses and, at times, inconvenience, they have not produced dramatic shifts in average auto occupancy rates. Employees tend to resist a vigorously promoted carpool program, and the observed shifts in a firm's average auto occupancy rates rarely are more than 15%, i.e. from 1.2 to 1.3 persons/ auto. These rates might be significantly higher if the carpool/ vanpool programs were coupled with restrictions on destination parking opportunities or increased taxes on the operation of low occupancy vehicles.

Findings: VMT and Emission Reductions:

Using the above empirically determined average auto occupancy rate changes, lower bound estimates of VMT and auto emission reductions are roughly 0.1% if pessimistic or lower bound responses to employerbased carpool matching programs are used. Optimistic projections of carpool response rates (15% increase) result in a reduction in VMT as large as 2-3% for some cities. Variations in these total estimates are due to uncertainties resulting from:

(a) uncertainties about carpool response rate;

(b) uncertainties about firm size assumptions concerning the minimum number of employees a firm must have in order to participate effectively in an employer-based matching program.

(c) uncertainties about the impacts of carpool/vanpool matching programs in areas serviced by transit.

(d) Uncertainties about leakage rates (increased demand for cars left at home)

The spatial distribution of activities within urban areas can be an important determinant of the effectiveness of transportation control plans in general and carpool/ vanpool matching programs in particular. The distribution of population and employment plays a key role. The decentralization of employment is an important characteristic of metropolitan areas often overlooked by many observers who tend to think that the CBD, or at least the central city has a dominant share of employment. In all four cities considered the suburban rings contain a majority of the population, and in three of the four, a majority of the employment. Trip tables of journey-to-work reveal that choice of mode to work varies significantly by workplace, as well as by residence and workplace combination. In each of the four cities the auto occupancy rates for work trips decline as the workplace moves further from the CBD.

Our case studies reveal that carpools/vanpools are much more likely to be successful if they match employees from a single firm, sharing common workplace and work hours, thereby minimizing the likelihood of riding with a "stranger." In addition to matching homogenous commuters, many analysts believe that increases in carpool/vanpool matchings will vary with firm size, increasing in a non-linier relationship to size the lower cutoff point being about 100-250 employees. Our firm size distribution calculations reveal that the average firm size distribution for the four cities studied is strongly skewed at the lower end - over 50% of an employment in all four SMSA's is in firms with fewer than 100 employees. This suggests an upper limit for matching penetration in these and similar areas. Table 1 gives percentage changes in persons/auto for various carpool responses for different firm size assumptions.

Since households that carpool/vanpool are likely to leave a vehicle at home which otherwise could not be used for non-work travel, it is likely that the increased availability of autos may induce more non-work travel. Estimates with TASSIM suggest that about 40% of reduced work trip VMT may be replaced by newly generated, non-work travel. Table 2 gives the percent reductions in area wide VMT and mobile source HC emissions associated with various carpool responses, taking into account induced travel.

TABLE 2

PERCENT REDUCTION IN AREAWIDE VMT & MOBILE SOURCE HC EMISSIONS FOR FOUR METROPOLITAN AREAS WITH VARIOUS CARPOOL RESPONSES

Item	Pessimistic+	Optimistic 250+	Optimistic 100+
BOSTON			
VMT	0.124	1.99	2.64
HC	0.121	1.95	2.59
VMT-Induced	0.074	1.19	1.58
HC-Induced	0.073	1.17	1.55
LOS ANGELES			
VMT	0.185	1.76	2.43
HC	0.183	1.74	2.40
VMT-Induced	0.111	1.06	1.46
HC-Induced	0.110	1.05	1.44
CHICAGO			
VMT	0.22	2.4	3.1
HC	0.22	2.4	3.1
VMT-Induced	0.13	1.4	1.9
HC-Induced	0.13	1.4	1.9
WASHINGTON			
VMT	0.12	1.8	2.6
HC	0.12	1.8	2.6
VMT-Induced	0.07	1.1	1.6
HC-Induced	0.07	1.1	1.6

Source: Interpolations of results from TASSIM simulations.

+As explained in detail in text, 250 and 100 refer to the number of employees in the firm size considered; optimistic and pessimistic refer to the assumptions made in auto occupancy rate changes.

(B) Preferential Lanes

Improved transit performance has also been suggested as a policy that can be used to reduce VMT and vehicular emissions, but transit improvements in the form of new transit systems have proven to be very costly. Accordingly there have been many recent efforts to improve service performance with existing facilities. The dedication of roadway lane(s) to high occupancy vehicles during rush hours is the transit improvement considered in this study.

The impact of preferential lanes as represented by a 20% reduction in travel time, in the four urban areas considered has been estimated to reduce VMT by 1%. These reductions in VMT occur because the travel time improvements made possible by the lanes make the high occupancy vehicles permitted to use the lanes attractive relative to the single occupancy vehicles caught in rush hour traffic. For this reason buslanes are effective only on certain densely populated worktrips where congestion presents significant problems.

In addition to these limitations on possible implementation areas, preferential lanes' effectiveness is also limited by direct competition between two of the program's goals - increasing transit ridership and reducing automobile emissions. Park 'n ride facilities are frequently implemented in conjunction with preferential lanes as they seem to be a proven means to further increase express bus/carpool partonage. However, since cold start emissions are much greater than hot running emissions, the use of autos to reach a transit borading poing means that auto emissions decline less than VMT. Calculated estimates of % reductions in VMT and HC emissions for the four cities are given in the following table.

PERCENT REDUCTION IN AREA-WIDE VMT AND HC EMISSIONS
FROM AREAWIDE OR SPECIFIC CORRIDORS
A 20% Decrease in Travel Time

Item	Boston	Los Angeles	Chicago	Washington
VMT	0.50	0.62	0.4	1.1
HC Emissions	0.39	0.46	0.3	0.9

Source: TASSIM results and extrapolations of TASSIM results.

Developing cost estimates for a transit improvement program that would reduce transit travel time in each of the four cities by 20 percent is very difficult. Reserved bus lanes might improve transit performance in parts of the four metropolitan areas. The costs for existing bus lanes vary tremendously, with some lanes being quite cost effective and others not. More detailed analysis on a corridor-by-corridor basis in each city is necessary in order to produce estimates of the costs of improving transit performance with bus lanes. The value of a one percent reduction in VMT does suggest, however, that investments in extensive fixedrail transit systems would not be justified in terms of the reductions in VMT they could be expected to create.

Since transit serves dense CBD-destinations especially well, cities with higher shares of auto worktrips should experience largest impact of improved transit. Accordingly for the four cities studied improved transit is expected to have the largest impact in Washington, D.C., and the smallest impact in Chicago.

Summary

Our cost effectiveness analyses suggest that employer-based carpool matching programs are quite attractive in the four urban areas even if they only reduce VMT by one- or two-tenths of a percent. In the absence of negative constraints on driving, voluntary carpool programs can not be expected to achieve more than 3 or 4% reductions in VMT. The costs of improved transit service are difficult to estimate, but some bus lane proposals are likely to be cost effective. The savings from reductions in VMT from improved transit performance are probably not large enough to justify investments in fixed rail systems, however.

A final point worth emphasizing is that transit and carpools appear to be highly substitutable modes for many travelers. This finding suggests that carpooling programs should not be vigorously promoted in areas where a large proportion of the workforce uses transit. The data suggest that extremely high transit usage occurs mainly in CBDs. However since CBDs typically contain less than 10 percent of a metropolitan area's employment, carpool matching programs appear to have a wide potential market.

The small reductions in VMT and auto emissions that are projected from carpool/vanpool and transit improvement policies appear to be disappointing. These magnitudes testify to the difficulties of getting Americans to use their cars more intensively or to use transit instead of autos. The non-coercive policies analyzed here do not have a large impact in relative terms. They are voluntary programs. If coupled with restrictions on destination parking opportunities or higher user taxes for low occupancy vehicles the reductions might be significantly greater, although they then would probably be subject to significant public opposition.

The voluntary policies studied here, although yielding small percentage reductions, do have a large impact in terms of the total amount of money, miles and energy saved. Table 3 presents order of magnitude estimates of daily and annual VMT in the four case cities. It also displays the dollar value of one percent of annual VMT in each of the four cities by valuing VMT at six cents a mile, an amount that approximates the out-of-pocket operating costs for automobiles. This rather conservative valuation suggests that a one percent reduction in annual VMT would produce annual savings of $4 million in Boston to $28 million in Los Angeles. Valuations are also shown for a one-tenth of a percent reduction in VMT for the four cities. Finally, Table 13 shows the approximate costs of carpool programs in the four cities. Carpool matching programs appear to be cost effective even if they reduce VMT by as little as one-tenth of a percent.

TABLE 3

ANNUAL VALUES OF REDUCTIONS IN AREA-WIDE VMT

	Boston	Los Angeles	Chicago	Washington
Approximate daily VMT	$20x10^6$	$130x10^6$	$53x10^6$	$22x10^6$
Daily VMT x 365	$7.3x10^9$	$47.5x10^9$	$19.3x10^9$	$8.0x10^9$
1.0 Percent of Annual VMT	$73x10^6$	$475x10^6$	$193x10^6$	$80x10^6$
Value of 1% Reduction at 6¢/mile	$4,380,000	$28,500,000	$11,500,000	$4,800,000
Value of 0.1% Reduction at 6¢/mile	$438,000	$2,850,000	$1,158,000	$480,000
Approximate Cost of Present Car-pool Program	$600,000	$1,000,000	($270,000)	$150,000

Notes: a) Boston and Los Angeles VMT are scaled to the metropolitan area from TASSIM estimates for the two air quality control regions; Washington VMT is from G. Wickstrom, "What Transportation Planners Need," Proceedings of the National Conference. Chicago VMT is scaled from Washington VMT using population.

ABSTRACT

Our cost-effectiveness analyses suggest that employer-based voluntary carpool and vanpool matching programs are quite attractive in the four urban areas studied. The reductions in VMT can reach 2 to 3% even in the complete absence of any mandatory restrictions. These seemingly small reductions represent big reductions in VMT, and big savings in dollars for the user public. For example, a simple 1% reduction in the Washington, D. C. annual VMT represents an 80 million VMT reduction, and a cash savings of $4,800,000 to travelers - all at a meager expense of $150,000 - the savings would be seven times as great in Los Angeles. Similarly improved existing lane capacity (HOVL) for auto to bus use (during peak congestion hours) can yield 1/2 to 1% reductions in VMT, and consequent cash savings to travelers. These results indicate that voluntary carpools and vanpool matching programs, and HOVL's can be quite cost-effective even at very low VMT reduction levels; it also shows, however, that these voluntary programs can not yield the high reduction characteristics of programs that would utilize mandatory restrictions as well.

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PART A: EFFECTIVENESS ANALYSIS CALCULATIONS

Chapter 1: Summary of Effectiveness Analysis Calculations

(1) Characteristics of the Four Cities Analyzed

To understand how various transportation control programs will work in a particular city, it is ultimately necessary to analyze the programs for that city, yet much can be learned about the range of effects of control programs by analyzing their impacts in several cities with widely varying characteristics. The four cities included in this analysis, Boston, Los Angeles, Chicago and Washington, cover a wide range of employment and population densities, spatial organizations, transit usage rates, and temporal growth paths. At one extreme is Boston: an old, high density northeastern city with an extensive transit system; at the other extreme is Los Angeles: a new, low density southwestern city with an auto-oriented development pattern. Chicago and Washington, D.C. fall somewhat between these two cities in terms of their age and development patterns.

Table 1.1 reveals that Boston and Washington are very similar in total population and that their central cities contain only about one-quarter of their metropolitan area populations. Los Angeles and Chicago, which are also similar to each other in size at the metropolitan level, have relatively large central cities that contain nearly half of their metropolitan area population. In terms of area, Boston is the smallest SMSA and Los Angeles the largest. In area, as in population, the central cities of Los Angeles and Chicago are much larger than the central cities of Boston and Washington.

Figure 1 shows how the populations of the four central cities have changed over the past 110 years. Los Angeles has the only central city that is still growing; the populations of the other three cities peaked

TABLE 1.1

POPULATION AND AREA OF FOUR URBAN AREAS

Item	Urban Area Boston	Los Angeles	Chicago	Washington
SMSA Population in 1970	2,754,000	7,041,000	6,978,000	2,862,000
Central City Pop'n in 1970	641,000	3,169,000	3,367,000	757,000
City's Percent of SMSA Population	22.1%	45.1%	48.2%	26.0%
SMSA Area (Sq. Miles)	1288	4069	3719	2812
City Area	46	455	222	61
City's Percent of SMSA Area	3.6%	11.2%	6.0%	2.2%

Source: Statistical Abstract of the United States, 1973. Population figures are from Urban Data Book, U.S. Department of Transportation, Report No. DOT-TSC-OST-75-45 (November 1975). All data based on U.S. Census.

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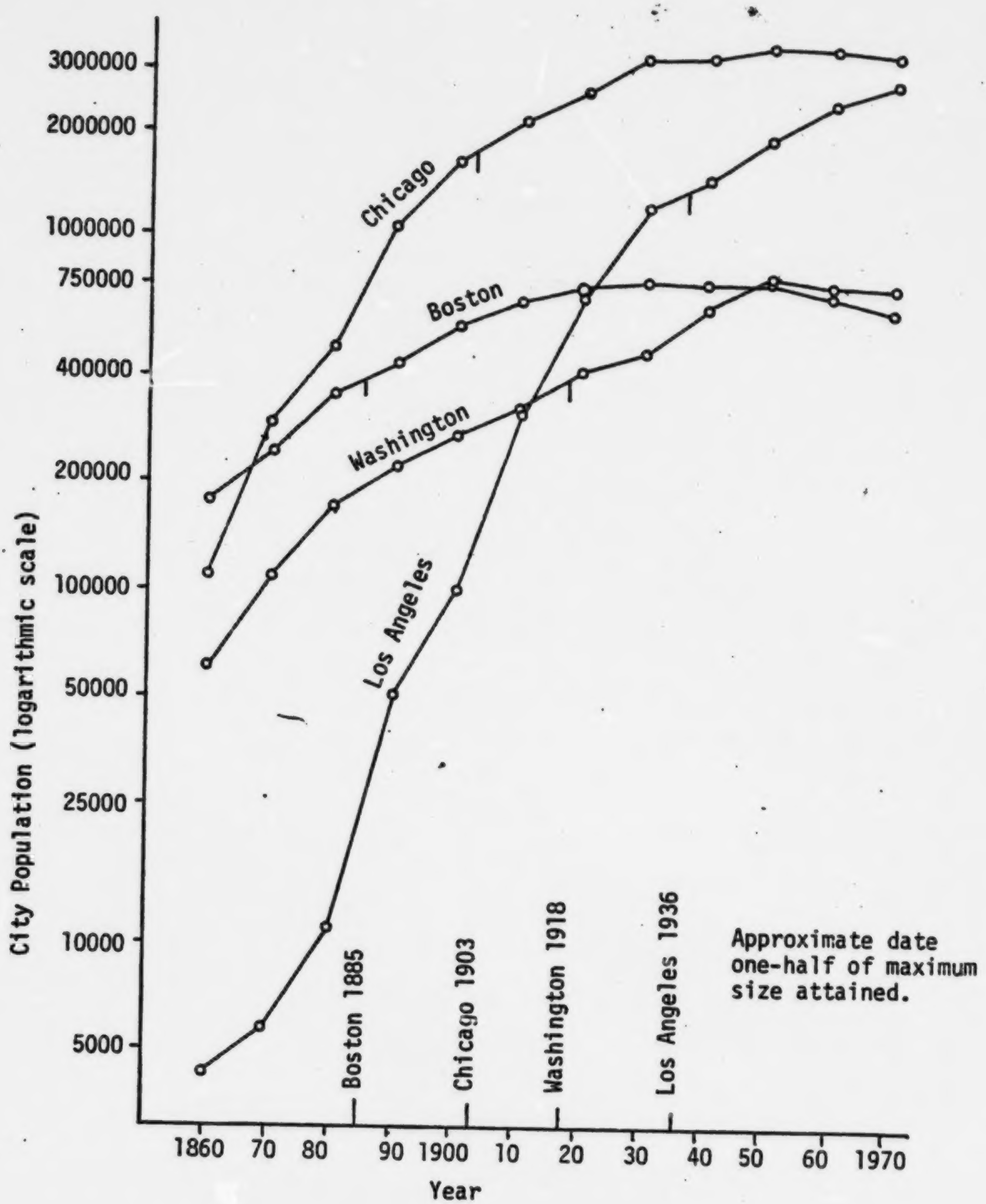
FIGURE 1.1

Population Growth Pattern of Four Cities



Source: Statistical Abstract of the United States, various.

in 1950 and have since declined. Figure 1.1 can be used to characterize the four cities in terms of their "age." A common way of measuring a city's "age" is to determine the date at which it reached half of its maximum population.* These dates are noted for each city on Figure 1.1. By this definition Boston is the oldest and Los Angeles the youngest of the four cities. This measure of city age is useful because it indicates the time period in which the city was laid out and provides some information about the age of the housing stock and the type of transportation available. For example, the two older cities have extensive transit systems while Los Angeles relies largely on automobiles for urban travel.

The spatial distribution of activities within urban areas can be an important determinant of the effectiveness of transportation control programs, and Table 1.2 provides summary information about the distribution of population and employment within the four cities. Data are shown for the central business district (CBD), the central city other than the CBD, and the metropolitan area other than the central city. These areas roughly comprise the center and two concentric rings. The distributions of population shown in Table 2 mirror the numbers shown in Table 1: in all four areas more than half of the population lives outside of the central city and very small proportions of the populations live in the CBDs. The distributions of employment in Table 2 show that employment is nearly as suburbanized as population. Chicago is the only one of the four areas where the suburban ring contains less than half of the SMSA's employment. The CBDs in the four cities contain a large number of jobs

---

*James Heilbrun, Urban Economics and Public Policy (New York: St. Martin's Press, 1974), p. 36.

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TABLE 1.2

EMPLOYMENT AND POPULATION DISTRIBUTIONS IN FOUR METROPOLITAN AREAS

	Employment			Population		
Location	Jobs	Percent	Jobs/Sq.Mi.	Persons	Percent	Pop./Sq.Mi.
			BOSTON			
CBD	91,000	7.6	91,000	3,700	0.1	3,700
Rest of C.C.	351,000	29.3	7,800	637,000	23.1	14,155
SMSA Other than C.C.	757,000	63.1	609	2,113,000	76.7	1,701
Totals	1,199,000	100.0		2,754,000	100.0	
			LOS ANGELES			
CBD	143,000	4.3	51,800	22,150	0.3	8,025
Rest of C.C.	1,446,000	43.9	3,200	3,147,000	44.7	6,960
SMSA Other than C.C.	1,707,000	51.8	472	3,872,000	55.0	1,071
Totals	3,296,000	100.0		7,041,000	100.0	
			CHICAGO			
CBD	252,000	8.3	163,000	4,826	0.1	3,113
Rest of C.C.	1,413,000	46.4	6,400	3,364,000	48.2	15,256
SMSA Other than C.C.	1,379,000	45.3	394	3,609,000	51.7	1,032
Totals	3,044,000	100.0		6,978,000	100.0	
			WASHINGTON			
CBD	147,000	11.7	106,500	5,105	0.2	3,700
Rest of C.C.	424,000	33.8	7,111	752,000	26.3	12,616
SMSA Other than C.C.	683,000	54.5	248	2,105,000	73.5	765
Totals	1,254,000	100.0		2,862,000	100.0	

Source: Urban Data Book, U.S. Dept. of Transportation, Report No. DOT-TSC-OST-75-45, II. (November 1975). Based on 1970 Census data.

in absolute terms, but the CBDs' share of metropolitan area employment is small, exceeding 10 percent only in Washington, D.C. The decentralization of employment is an important characteristic of metropolitan areas that is often overlooked by many observers who tend to think that the CBD, or at least the central city, has a dominant share of employment.

The popular belief that most jobs are in CBDs undoubtedly stems from observations of the CBDs' high employment densities. The employment densities in Table 1.2 are always an order of magnitude larger for the CBD than for the rest of the central city. The employment and population densities of Washington and Boston are very similar for the CBD and central city, but Boston's suburban ring is more dense than Washington's. Chicago has very high employment densities in its CBD while Los Angeles' CBD has the lowest employment density of the four cities. The density of both employment and population in Los Angeles' suburban ring is similar to that found in Chicago and Washington, while Boston clearly has the highest density suburban ring.

The spatial distributions in these four cities have several similarities. The suburban rings in all four cities contain a majority of the population, and in three of the four a majority of the employment. It is apparent that the typical worker in these urban areas may live in the suburbs, but he is unlikely to work in the CBD since most workers are employed in the suburbs or the non-CBD central city.

Table 1.3 displays the interactions between residential locations and workplaces for the four cities in terms of a trip table with three residence locations and three workplaces. The entries in each trip table are percents of the metropolitan area's total worktrips. For example,

TABLE 1.3

PERCENT OF TOTAL WORKTRIPS FROM RESIDENCE TO WORKPLACE FOR FOUR METROPOLITAN AREAS

Residence Location	Workplace CBD	Non-CBD Central City	Ring	Total
		BOSTON		
Central City	3.0	13.5	4.5	21.0
Ring	4.3	13.3	50.1	67.7
Outside SMSA	0.3	2.5	8.5	11.3
Total	7.6	29.3	63.1	100.0
		LOS ANGELES		
Central City	2.4	28.2	12.2	42.8
Ring	1.8	15.3	37.8	54.9
Outside SMSA	0.2	0.5	1.8	2.5
Total	4.3	43.9	51.8	100.0
		CHICAGO		
Central City	5.3	35.0	7.4	47.7
Ring	3.0	11.0	36.7	50.7
Outside SMSA	0.1	0.5	1.2	1.8
Total	8.3	46.4	45.3	100.0
		WASHINGTON		
Central City	4.7	16.8	4.7	26.2
Ring	6.7	15.6	46.4	68.7
Outside SMSA	0.3	1.4	3.3	5.0
Total	11.7	33.8	54.5	100.0

Source: Urban Data Book, U.S. Dept. of Transportation, Report No. DOT-TSC-OST-75-45.II (November 1975).

34.

the Boston trip table shows that 50.1 percent of all Boston area worktrips have both their origin and destination in the suburban ring. For all four cities ring-to-ring trips comprise the largest share of worktrips, although only in Boston does this category contain a majority of worktrips. The trip table for Boston is similar to that for Washington, while the table for Los Angeles is similar to that for Chicago. The reasons for this pairwise similarity are contained in Table 1.4, which showed that Boston and Washington have small central cities while Los Angeles and Chicago have large central cities.

The importance of the trip table becomes apparent when data on mode choice are examined because the choice of mode to work varies significantly by workplace, as well as by residence and workplace combination. In most metropolitan areas the transit system has a strong radial orientation to the CBD. That is, transit service is best between the CBD and outlying areas. Transit service between points outside the central city is often either non-existent or else very time consuming because the traveler must go into the CBD on one radial segment and out from the CBD on another radial segment. The poor service entailed by such circuitous routing often means that very few trips with both an origin and a destination in the suburban ring will be made on transit. Often, in addition, it is difficult to use transit to make worktrips from the center to outlying areas because of scheduling problems or poor transit service to suburban workplaces.

Table 1.4 displays worktrip mode choice data by workplace for the four urban areas. The data in Table 1.4 were derived from a census one percent sample of each of the SMSAs. The census mode choice data are

TABLE 1.4

WORKTRIP MODE SPLIT AND AUTO OCCUPANCY BY WORKPLACE FOR FOUR METROPOLITAN AREAS

Workplace Location	Mode Split (Percent)						Persons Per Auto
	Auto Driver	Auto Passenger	Transit	Walk	Taxi	Other	
BOSTON							
CBD	29.0	7.6	57.4	4.8	0.6	0.6	1.26
Rest of Central City	49.2	11.3	25.6	10.7	1.5	1.8	1.23
SMSA Other than C.C.	65.6	13.1	7.4	9.4	0.7	3.9	1.20
All	58.0	11.6	17.0	9.5	1.0	2.9	1.21
LOS ANGELES							
CBD	62.2	13.1	22.2	1.2	0.0	1.3	1.21
Rest of Central City	76.8	8.4	6.4	4.4	0.0	3.9	1.11
SMSA Other than C.C.	80.5	8.9	2.5	4.2	0.1	3.8	1.11
All	78.2	8.6	5.2	4.1	0.1	3.8	1.11
CHICAGO							
CBD	18.8	3.7	75.6	1.1	0.5	0.4	1.20
Rest of Central City	49.8	9.5	30.3	8.3	0.3	1.9	1.19
SMSA Other than C.C.	70.6	13.4	5.8	5.7	0.3	4.1	1.19
All	57.0	10.8	22.6	6.5	0.3	2.8	1.19
WASHINGTON							
CBD	39.0	18.0	35.4	4.0	1.9	1.3	1.46
Rest of Central City	54.2	14.1	22.6	5.0	1.4	2.7	1.26
SMSA Other than C.C.	72.0	11.5	5.8	5.2	0.8	4.6	1.16
All	62.2	13.1	14.9	5.0	1.2	3.6	1.21

Source: 1970 Census Public Use Data.

presented in eight categories and have been collapsed to six in Table 4. The persons per auto figure in Table 4 has been calculated by dividing the sum of auto drivers and auto passengers by the number of auto drivers.*

Uniformly across the areas transit's share declines and the share of auto driver trips increases as the workplace moves away from the CBD. Walking is one mode often overlooked by transport planners, and Table 1.4 reveals its importance. In Los Angeles, walking is only slightly less popular than transit as a mode to work.

In each of the four cities the auto occupancy rate for worktrips declines as the workplace moves further from the CBD. The high auto occupancy rates in the Washington CBD undoubtedly reflect the impact of the federal employees carpooling program that has been encouraged there for many years. It is very interesting to contrast the workplace change in auto occupancy rates with the workplace change in the share of worktrips made by auto passengers. The auto passenger share is a measure of carpooling activity, and it increases with distance from the CBD in Boston and Chicago, but decreases with distance from the CBD in Los Angeles and Washington. The low share of auto passenger trips made to the CBD in Boston and Chicago is likely due to the presence of extensive transit systems in those two cities, and these data suggest that carpooling and transit may be competing modes.

The data presented thus far outline many differences and similarities among the four cities selected for analysis. These descriptive data also provide a basis for the analysis of carpooling and transit improvement programs that are described in the next sections.

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*Since Table 4 was derived from census data that is available for the 125 largest SMSAs, it was a simple matter to produce tables similar to Table 4 for each metropolitan area. These are reproduced in Appendix A of this paper.

C. Analysis of Voluntary Carpooling Matching Programs

Carpooling and other high occupancy vehicle policies such as van pools have attracted a great deal of enthusiasm in the past few years as techniques for reducing vehicles miles of travel in urban areas. These policies have many strengths: they use existing facilities and do not call for massive public or private investments; they can be as efficient as some higher occupancy modes such as buses; they involve few public employees; and they have the potential to serve virtually any location presently accessible by automobile. The major difficulty with high occupancy vehicle policies is their service characteristics. Car and van pools have particularly inflexible schedules: the service is offered once a day to a member, and changes in trip times generally require the consensus of all members. In addition, commuting pools are often difficult to set up because individuals who may want to pool can have a difficult time coming in contact with others wishing to form carpools.

The difficulty of finding other potential riders for commuting pools has been reduced significantly in many metropolitan areas by publicly supported voluntary carpool matching programs. Perhaps the major service of the programs is their reduction of the "transaction costs" involved in forming carpools. Voluntary matching programs solicit information from commuters and then try to match groups by origin, destination, and time of travel. The results of these voluntary matching programs are reported in several case studies discussed in Appendicies C and D* Typically, the number of successful carpool matches formed by areawide carpool matching programs has been very small. Experience suggests that carpools are much more likely to be successful if they involve employees from a single firm. Such individuals are less likely to be strangers, and they typically have a common workplace and common work hours, so residential location becomes the major dimension requiring commonality. As a result, most metropolitan carpooling programs are now employer-based.

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*Also see William L. Berry, "On the Economic Incentives for Commuter Carpooling" DBA thesis - Harvard University, 1975.

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Theoretical work done with carpool matching data implies that the proportion of applicants to a carpool program that is successfully matched will increase with the number of applicants.* This result has led designers of employer-based carpool programs to solicit potential carpool applicants only from large firms. For example, in Boston the new Mass Pool program deals only with firms who have 250 or more employees.

Given the new popularity of employer-based programs, this section projects the impacts that a voluntary employer-based carpool matching program would have in the four cities described in Section B. This analysis requires three major steps. First, data are presented on the "dose-response" relationship between carpooling programs and increases in carpooling. Second, the pool of potential candidates is defined in terms of distributions of employment by firm size. Finally, the "dose-response" relation is applied to the pool of potential candidates to determine the effect that a voluntary matching program would have on vehicle miles traveled in each of the four metropolitan areas.

1. Matching Programs and Auto Occupancy Rates. Since relatively few of the earlier carpool matching programs were employer-based, data

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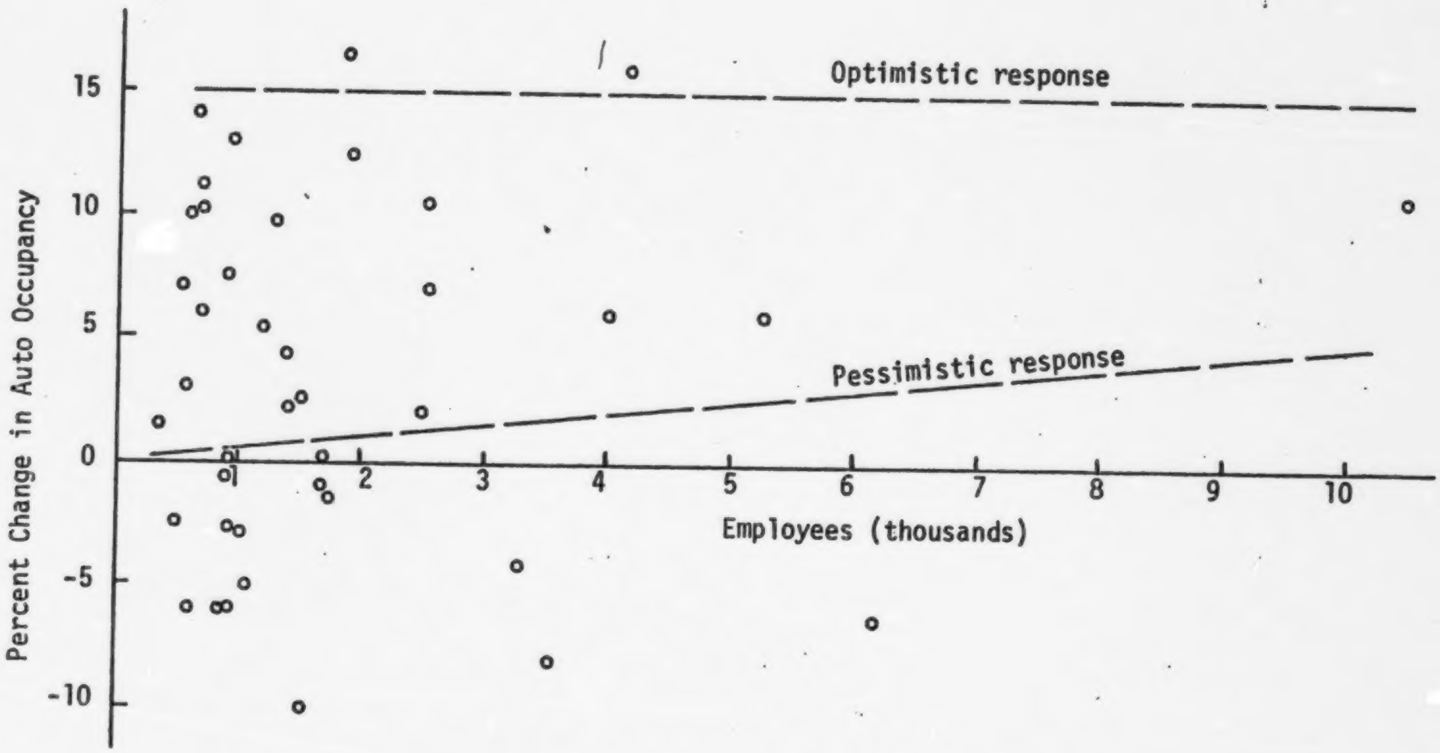
*William L. Berry, op. cit.

linking changes in carpooling rates to the application of an employer-based voluntary carpool matching program are relatively rare. Data are available from 42 New Jersey firms that participated in a carpool matching program begun in the winter of 1973/74 during the energy crisis. Changes in carpooling activity are measured in terms of the percent change in each firm's auto occupancy rate. The change in the auto occupancy rate compares the pre-program rate to the auto occupancy rate 18 months later.

Figure 1.2 relates the change in auto occupancy rates to firm size, and reveals that there is not a strong firm size effect. The decline in auto occupancy rates for many of the firms is attributable to firm-specific employment reductions that disrupted carpools, and to the high level of voluntary carpooling that existed during the 1973/74 energy crisis. Given the wide distribution of the data in Figure 1.2, two potential extremes of responses to an employer-based carpool matching program are hypothesized. An optimistic response is defined by the upper bound of points as approximately a 15 percent increase in auto occupancy rates, independent of firm size. A pessimistic response is defined by the lower bound of positive changes; it increases linearly with firm size from zero at a firm size of zero to five percent at a firm size of 10,000. These responses serve to bound the experience of firms in other areas. For example, the 3-M Corporation (9,000 employees) has increased occupancy rates of automobile commuters by over 12 percent from 1.23 in 1970 to 1.38 in 1974. The two hypothesized responses to carpool matching programs should provide upper and lower bounds for the increase in vehicle occupancy rates attributable to voluntary matching programs.

FIGURE 1.2

Change in Auto Occupancy for New Jersey Firms



2. Distribution of Employment by Firm Size. The distribution of employment by firm size is important because many analysts believe that the increase in carpooling obtained will vary with firm size. Although the data in Figure 1.2 do not suggest such a relation, they are certainly not the final word on this matter. Furthermore, the smallest firm shown in Figure 1.2 has 350 employees, and there may well be a firm size effect for firms with fewer than 350 employees. Since some employer-based programs have a minimum firm size requirement, the distribution of employment by firm size will show what proportion of workers will be eligible as the minimum size is varied.

Distributions of employment by firm size were estimated for each of the four case cities using data from 1973 County Business Patterns and the 1970 Census. The estimation procedure, which proved to be very tedious, is described in Appendix A. The results of the calculations are displayed in Tables 1.5, 1.6, and 1.7. Table 1.5 shows the average numbe of employees per firm for nine firm size categories. Most striking is the fact that the average firm sizes are typically near the bottom of each size category, indicating that the firm size distribution is strongly skewed. Note that all of the firm size data exclude public administration employees. Table 1.6 displays the average percent of employment by size category for the central city and suburban ring of each metropolitan area. This table shows that large firms account for slightly larger shares of employment in the central city relative to the suburbs in all four areas. Finally, Table 1.7 shows the cumulative distribution of employment by firm size. There are obviously some differences in the size distributions of employment across these four areas, with

TABLE 1.5

AVERAGE NUMBER OF EMPLOYEES PER FIRM BY FIRM SIZE CATEGORY IN FOUR METROPOLITAN AREAS

Area	Firm Size Category 1-49	50-99	100-249	250-499	500-999	1000-1499	1500-2499	2500-4999	5000+
Boston	5.85	61.7	117.9	273.7	510.7	1109.0	1606.3	2773.9	6754.0
Los Angeles	7.07	67.4	150.0	335.8	629.5	1275.3	1766.4	3340.2	9894.2
Chicago	6.91	60.9	137.7	320.9	598.0	1205.6	1607.3	2924.6	9844.2
Washington	7.60	62.3	137.2	312.4	586.3	1290.0	1932.6	3644.8	10773.0

Source: Based on 1973 County Business Patterns and 1970 Census.

Note: Excludes Public Administration Category.

TABLE 1.6

PERCENT OF EMPLOYMENT BY FIRM SIZE
IN FOUR METROPOLITAN AREAS

Location	Firm Size Category 1-49	50-99	100-249	250-499	500-999	1000-1499	1500-2499	2500-4999	5,000+
				BOSTON					
Central City	31.36	11.51	15.67	10.99	8.84	5.30	5.09	4.56	6.68
Ring	36.60	11.47	13.76	10.04	8.67	5.11	4.69	4.18	5.48
				LOS ANGELES					
Central City	36.28	11.12	14.31	9.26	8.13	4.18	3.34	4.60	8.78
Ring	37.66	11.39	14.41	9.69	7.85	3.96	2.93	4.07	8.04
				CHICAGO					
Central City	29.43	10.46	14.85	11.08	9.17	5.52	5.15	5.88	8.46
Ring	31.34	10.37	14.28	11.80	8.92	5.27	4.65	5.36	8.01
				WASHINGTON					
Central City	34.66	11.33	14.13	11.10	6.38	5.38	5.84	7.99	3.19
Ring	42.77	12.46	14.88	8.90	6.41	5.36	2.70	4.01	2.51

Source: Based on 1973 County Business Patterns and 1970 Census.

Note: Excludes Public Administration Category.

TABLE 1.7

CUMULATIVE PERCENTAGE DISTRIBUTIONS OF EMPLOYMENT BY FIRM SIZE CATEGORY IN FOUR METROPOLITAN AREAS

Location	Firm Size Category 1-49	50-99	100-249	250-499	500-999	1000-1499	1500-2499	2500-4999	5,000+
BOSTON									
Central City	31.36	42.87	58.54	69.53	78.37	83.67	88.76	93.32	100.00
Ring	36.60	48.07	61.83	71.87	80.54	85.65	90.34	94.52	100.00
LOS ANGELES									
Central City	36.28	47.40	61.71	70.97	79.10	83.28	86.62	91.22	100.00
Ring	37.66	49.05	63.46	73.15	81.00	84.96	87.89	91.96	100.00
CHICAGO									
Central City	29.43	39.89	54.74	65.82	74.99	80.51	85.66	91.54	100.00
Ring	31.34	41.71	55.99	67.79	76.71	81.98	86.63	91.99	100.00
WASHINGTON									
Central City	34.66	45.99	60.12	71.22	77.60	82.98	88.82	96.81	100.0
Ring	42.77	55.23	70.11	79.01	85.42	90.78	93.48	97.49	100.0

Source: Based on 1973 County Business Patterns and 1970 Census.

Note: Percent distributions exclude workers in public administration category.

Chicago having many large firms and Washington many small firms. For example, Table 1.7 shows that only 30 percent of the private sector employment in Washington's suburbs is in firms with 250 or more employees, while in Chicago roughly 45 percent of employment is in such firms. In all four cities about 15 percent of employment is in the category 100-249, so that from 45 percent (Washington suburbs) to 60 percent (Chicago) of private sector employment is in establishments with more than 100 employees. These figures make it apparent that the minimum required firm size for employer-based carpooling programs must be selected carefully since moving the point from 250 down to 100 can have such a large impact on the percentage of the workforce that will be eligible for carpooling. Accordingly, carpool response estimates will be presented here for minimum required firm sizes of both 100 and 250 employees.

Since all of the firm size distributions exclude public administration workers, Table 1.8 shows the percent of the workforce that is in the public administrative category in each of the four case cities. As expected, this group comprises a very large share of employment in Washington, but less than 10 percent of employment in the other three cities. Since comparable data on establishment size for public administration workers is just not available for the four cities, we will assume that the distribution of employment by firm size in public administration is similar to the distribution in the private sector. If this proves to be a poor assumption, it will clearly produce the largest biases in Washington.

TABLE 1.8

PUBLIC ADMINISTRATION WORKERS AS PERCENT OF TOTAL WORKFORCE

Metropolitan Area	Central City	Ring
Boston	8.4	5.1
Los Angeles	6.2	8.2
Chicago	5.5	5.8
Washington	35.9	26.3

Source: 1970 Census.

3. Reductions in VMT from Carpool Matching Programs. Given the "dose-response" relations derived from Figure 1.2 and the distribution of employment by firm size, a range of carpool induced changes in auto occupancy rates can be calculated for each of the four case cities. The results of this calculation are summarized in Table 1.9, along with some basic data from each of the case cities.

The overall auto occupancy rates for Boston and Los Angeles were obtained from the 1963 and 1968 home interview surveys carried out in the two cities. The overall average auto occupancy rates for Chicago and Washington are estimates based on the Boston and Los Angeles figures. The worktrip auto occupancy figures for the four cities are the census-based rates reported in Table 1.4 above. The worktrip shares of VMT in Boston and Los Angeles are based on the Boston and Los Angeles survey data, and the Washington figure is from a paper by Horowitz and Pernela.* The worktrip share of VMT for Chicago is an estimate based on worktrips' share of total trips there.

The final row of figures presented as "basic data" is the elasticity of the overall auto occupancy rate with respect to the worktrip occupancy rate. This elasticity, which is derived in Appendix A, equals the proportion of VMT from worktrips divided by one minus the non-worktrip proportion of VMT times the proportional change in the worktrip auto occupancy rate. Since the elasticity varies with the change in worktrip auto occupancy rates, Table 1.9 reports the elasticity for a .05, or five percent, proportional increase in the worktrip auto occupancy

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*Joel Horowitz and Lloyd Pernela, "Comparison of Automobile Emissions According to Trip Type in Two Metropolitan Areas," presented at the 54th Annual TRB Meetings (January 1975).

TABLE 1.9

PERCENT CHANGE IN PERSONS PER AUTO (PPA) FOR VARIOUS CARPOOL RESPONSES

Item	Boston	Los Angeles	Chicago	Washington
Basic Data				
Average PPA	1.40	1.39	1.4	1.4
Worktrip PPA	1.21	1.11	1.19	1.21
Worktrip Share of VMT	.38	.35	.40	.38
Elasticity of Total PPA with Respect to Worktrip PPA	.368	.339	.388	.368
Percent Increase in Worktrip PPA for Various Carpool Responses				
Pessimistic	0.363	0.583	0.599	0.358
Optimistic - 250	6.03	5.72	6.74	5.32
Optimistic - 100	8.10	7.98	8.92	7.97
Percent Increase in Overall PPA for Various Carpool Responses				
Pessimistic	0.138	0.203	0.239	0.136
Optimistic - 250	2.21	1.93	2.59	1.96
Optimistic - 100	2.93	2.66	3.39	2.89

Source: See text for derivation.

rate. For example, .368 = .38/(1+.62·.05). This elasticity and the following calculations implicitly assume that increases in auto occupancy rates in worktrips result from redistributing existing auto travelers among vehicles and that no travelers on other modes, e.g., transit, are diverted to carpools by a matching program. Since a matching program is likely to divert some CBD or central city workers from transit to carpools, the calculations presented here may overstate the reduction in VMT attributable to carpools. After presenting the first round of reductions, an attempt will be made to correct the VMT figures for transit diversion.

Returning to Table 1.9, its second section shows the increase in worktrip auto occupancy rates for the three different hypothesized responses to a carpool matching program. The row labeled "pessimistic" assumes that worktrip auto occupancy rates will increase in percentage terms by .0005 times the number of employees in the firm. This calculation is done for firms with 250 or more employees and provides a lower bound for the impact that a matching program would have on worktrip auto occupancy. The rows labeled "optimistic-250" and "optimistic-100" assume that worktrip auto occupancy rates will increase by 15 percent for firms with 250 or more and 100 or more employees, respectively. For Boston the optimistic-250 estimate is 6.03 percent because only about 40 percent of Boston employment is in firms with 250 or more employees, and .40 x .15 = .06. Differences in the estimated change in worktrip auto occupancy rates across the four cities are due to differences in the cities' distributions of employment by firm size.

The third section of Table 1.9 shows the increase in overall auto occupancy rates attributable to the increase in worktrip occupancy rates. It is obtained by multiplying the change in worktrip auto occupancy rates times the elasticity of the overall occupancy rate with respect to the worktrip occupancy rates. The change in overall auto occupancy rates ranges from nearly zero to three percent, a range that seems fairly small. It is easy to see that this is the right order of magnitude, however, since 40 percent of travel is for worktrips; 40 percent of the workers are affected; the change is 15 percent; and .4 x .4 x .15 = .024.

The next step in the analysis is to translate the increase in auto occupancy rates into a reduction in VMT and auto emissions. This translation was performed with the aid of TASSIM, a transportation and air shed simulation model.* This model has been calibrated to Boston and Los Angeles, and its results were extrapolated to Chicago and Washington in this analysis. The reductions that result from the various hypothesized carpooling responses are shown in Table 1.10. The first two rows for each city show the direct impact on travel assuming that the reduction in work travel is not accompanied by an increase in non-work travel. Since households that carpool are likely to leave a vehicle at home which others could use for non-work travel, it is likely that the increased availability of automobiles may induce more non-work travel. Estimates with TASSIM suggest that about 40 percent of the reduced worktrip VMT may be replaced by non-work travel, and this estimate has been confirmed by others.** The row headings labeled "induced" in Table 1.10.

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*For a description of TASSIM, see G. K. Ingram and G. R. Fauth, TASSIM: A Transportation and Air Shed Simulation Model, Final Report, DOT Contract DOT-OS-30099 (May 1974).

**TASSIM's estimate of induced travel from carpooling is based on Boston, and similar estimates have been derived from Washington data. See T. J. Atherton, J. H. Suhrbier, and W. A. Jessiman, "The Use of Disaggregate Travel Demand Models to Analyze Carpooling Policy Incentives," presented at the 55th Annual TRB Meeting (January 1976).

TABLE 1.10

PERCENT REDUCTION IN AREAWIDE VMT & MOBILE SOURCE HC EMISSIONS FOR FOUR METROPOLITAN AREAS WITH VARIOUS CARPOOL RESPONSES

Item	Pessimistic	Optimistic 250	Optimistic 100
	BOSTON		
VMT	0.124	1.99	2.64
HC	0.121	1.95	2.59
VMT-Induced	0.074	1.19	1.58
HC-Induced	0.073	1.17	1.55
	LOS ANGELES		
VMT	0.185	1.76	2.43
HC	0.183	1.74	2.40
VMT-Induced	0.111	1.06	1.46
HC-Induced	0.110	1.05	1.44
	CHICAGO		
VMT	0.22	2.4	3.1
HC	0.22	2.4	3.1
VMT-Induced	0.13	1.4	1.9
HC-Induced	0.13	1.4	1.9
	WASHINGTON		
VMT	0.12	1.8	2.6
HC	0.12	1.8	2.6
VMT-Induced	0.07	1.1	1.6
HC-Induced	0.07	1.1	1.6

Source: Interpolations of results from TASSIM simulations.

show the VMT and HC reductions net of the additional induced travel. Table 10 shows that worktrip carpool matching programs might reduce area-wide VMT by up to two percent, although a reduction between a tenth of one percent and one percent seems more likely. The figures in Table 10 that are corrected for induced non-work travel may still overstate the reduction in VMT due to carpooling because the calculations in Table 1.10 assume that no transit riders are diverted to carpools.

Diversion of transit riders to carpools interferes with the simple relation between auto occupancy rates and VMT that has been assumed so far. For example, suppose carpooling programs have the sole effect of turning transit passengers into carpool passengers. This would increase auto occupancy rates (and the mode share of auto passengers), but have no effect on VMT. Furthermore, the data in Table 1.4 suggested that carpools and transit may be viewed as substitutes, so some adjustment in projected VMT may be called for.

Table 11 presents some preliminary estimates of the relation between carpooling and transit ridership for 160 firms participating in the Massachusetts Mass Pool program. The regressions in Table 1.11 suggest, as did the New Jersey data in Figure 1.2, that the relation between carpooling and firm size is not strong, and that carpooling increases somewhat with wage rates. Most significantly, the regressions offer evidence that carpooling and transit ridership are substitutes. The calculated elasticities at the bottom of Table 1.11 indicate that transit and carpooling are stronger substitutes for central city than for suburban workers. Other studies have also found that transit and carpools are substitutes. For example, Atherton, Suhrbier, and Jessiman

TABLE 1.11

REGRESSION ANALYSIS OF CARPOOL CHOICE - 160 BOSTON AREA FIRMS

1. Entire Sample:

$$CP = \underset{(1.4)}{.137} + \underset{(0.7)}{.0092}LFS + \underset{(1.6)}{.00047}W - \underset{(2.7)}{.128}PUBTR - \underset{(1.2)}{.03}SUB \qquad R^2 = .13, \quad N = 160$$

2. Stratified Sample:

$$CPCC = \underset{(1.4)}{.162} + \underset{(0.3)}{.00394}LFS + \underset{(1.0)}{.00326}W - \underset{(2.8)}{.129}PUBTR \qquad R^2 = .07, \quad N = 77$$

$$CPSUB = \underset{(0.2)}{.046} + \underset{(0.8)}{.0183}LFS + \underset{(1.3)}{.00069}W - \underset{(0.8)}{.106}PUBTR \qquad R^2 = .01, \quad N = 83$$

Variables		Sample Mean
CP	= Proportion of work force commuting in multi-occupancy vehicles	.217
CPCC	= CP for central city firms	.181
CPSUB	= CP for suburban firms	.251
LFS	= Log of firm size (no. of employees)	6.44
W	= National average weekly earnings by S.I.C. code (from B.L.S. *Employment and Earnings*, April 1974)	141.
PUBTR	= Proportion of work force commuting by transit	.240
PUBTRCC	= PUBTR for central city firms	.428
PUBTRSUB	= PUBTR for suburban firms	.069
SUB	= Dummy variable (1 for suburban location; 0 for central city)	.519

Elasticity of carpooling with respect to transit ridership, evaluated at the means.

1. Entire Sample: -0.142
2. Central City: -0.305
3. Suburbs: -0.029

Note: Sample was compiled by A. M. Voorhees as part of the Massachusetts Mass Pool program. Numbers in parentheses are t-ratios.

estimate that in Washington, D.C. approximately one-quarter of new carpool riders attracted to carpools by an employer-based carpool incentive program would be diverted from transit.* If this diversion rate is applied to the other three cities in Table 1.10, the maximum reduction in VMT from the most optimistic program would be less than one and one-half percent.

From the point of view of designing carpool incentive programs, the diversion of commuters from transit can be reduced significantly by not offering a computer matching program to firms that have a large proportion of their workforce commuting by transit. The mode split figures in Table 1.4 suggest, for example, that employees of firms located in the Chicago or Boston CBD are heavy transit users, and that relatively little would be gained by offering them carpool matching services.

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*T. J. Atherton, J. H. Suhrbier, and W. A. Jessiman, op. cit.

D. Analysis of Improved Transit Performance: HOVL's

Improved transit performance has also been suggested as a policy that can be used to reduce VMT and vehicular emissions, but transit improvements in the form of new transit systems have proven to be very costly. Of course, there are ways to improve transit performance without making huge investments in new systems. In particular, transferring existing highway lanes from auto use to bus use has often been proposed as a relatively low cost way of improving transit service. The dedication of existing lanes to bus use improves transit performance only where highways are presently congested during rush hours. Thus, bus lanes are likely to improve transit service more in central city high density areas than in suburban areas where congestion is much less of a problem.

The evaluation of improved transit performance as a technique for reducing VMT and auto emissions was carried out for Boston and Los Angeles using the TASSIM model. In both cities the model was used to simulate the impacts of a 20 percent decrease in transit travel times over the existing areas served by transit. The reduction in VMT occurs because the improved transit performance makes it attractive for commuters and other travelers to use transit for all or part of their commute.

The results of the TASSIM simulations for Boston and Los Angeles are shown in Table 1.12. The 20 percent improvement in transit travel times reduces VMT overall by about a half percent in the two cities. The reduction in hydrocarbon emissions is less than the reduction in VMT because many commuters continue to use their cars to reach the transit system, and cold start emissions constitute a large share of total emissions for auto trips in urban areas.

TABLE I.12

PERCENT REDUCTION IN AREAWIDE VMT AND HC EMISSIONS FROM IMPROVEMENTS IN TRANSIT PERFORMANCE

(20% Decrease in Travel Time)

Item	Boston	Los Angeles	Chicago	Washington
VMT	0.50	0.62	0.4	1.1
HC Emissions	0.39	0.46	0.3	0.9

Source: TASSIM results and extrapolations of TASSIM results.

TABLE I.13

PERCENT OF AUTO WORKTRIPS BY WORKPLACE LOCATION

	CBD	Rest of Central City	Rest of SMSA	Total
Boston	4.0	25.5	70.8	100.0
Los Angeles	3.7	43.0	53.3	100.0
Chicago	2.8	41.8	56.4	100.0
Washington	8.9	30.7	60.5	100.0

Source: Calculated from Tables 3 and 4.

Since transit serves CBD-destined trips especially well, the extrapolations to Chicago and Washington were based on the current share of all auto trips that are made to the CBDs of the four cities. As shown in Table 1.13, in Boston and Los Angeles roughly four percent of all auto worktrips are made to the CBD, while the proportion is less in Chicago and more in Washington. The VMT reductions forecast for Chicago and Washington in Table 1.12 are based upon the importance of auto use for CBD-bound trips. Accordingly, improved transit is expected to have the largest impact in Washington and the smallest impact in Chicago. In both cities the forecast reduction in hydrocarbon emissions is less than the reduction in VMT because of the cold start emissions inherent in park and ride auto use.

F. Bibliography to Chapter 1

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Wickstrom, G. "What Transportation Planners Need," in M. M. Hufschmidt and A. C. Cooper, eds., Proceedings of the National Conference on Land Use Planning, Transportation Planning, and Air Quality Management. Chapel Hill, N.C.: Triangle Universities Consortium on Air Pollution, 1975.

APPENDIX A: Methodological Steps Performed in the Analysis

(1) Introduction

Summary

Changes in areawide VMT and hydrocarbon emissions that could be anticipated from a successful employer-based carpool promotion program and CBD-directed HOVL (high-occupancy vehicle lanes) in the four case-study cities were estimated by applying the Transportation Air Shed Simulation Model (TASSIM) or by calculations using TASSIM's conceptual structure. Using the most optimistic assumptions[1] concerning probable conditions that could occur in the cities following a vigorous promotion and implementation program, three primary conclusions were reached:

1. Between two and three percent reduction in areawide VMT could be expected from a carpool program directed at employers of 100 or more persons and achieving a 15 percent increase in employee automobile occupancy.

2. Not more than a one percent reduction in areawide VMT could be expected from a HOVL program that reduces overall transit time to the CBD (Central Business District) by 20 percent.

3. Reductions in hydrocarbon emissions would -- at best -- be equal to the reductions in VMT and would probably be less.

Methodological Approach

For two cities, Boston and Los Angeles, anticipated hydrocarbon emissions from (a) carpool programs and (b) HOVL development were estimated by simulation runs of TASSIM, based on their impact on automobile occupancy rates and transit travel times respectively. These results were then modified to reflect the altered circumstances of the other two cities, Washington and Chicago. The Boston application of

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[1] These include the highest estimated increase in average automobile occupancy rates for work trips to affected firms and no provision for the leakage of VMT reductions due to the induced use of cars formerly used for work trips.

TASSIM was calibrated with data from the 1963 Boston Metropolitan Area Transportation Survey and the 1970 Census. The Los Angeles version used data from a 1967 regional transportation survey and incorporated a mode-split model developed for the Los Angeles area by Alan M. Voorheees and Associates, Inc.[1] Although these data sources for Boston and Los Angeles are relatively old and possibly outdated, they are the only available, comprehensive, consistent regional transportation surveys and, therefore, the only data sources suited for the areawide analysis which TASSIM provides.

TASSIM uses the traditional UTP transportation model structure to ensure its compatibility with existing data sets for major metropolitan areas. In effect, TASSIM simulates transportation activities that concentrate emissions -- in this case, hydrocarbons -- in localized zones within a metropolitan area. The model normally consists of three major components -- a transportation sub-model, an emissions submodel, and an air diffusion submodel but only the transportation and emissions submodels were used in these analyses. The transportation submodel is based on the urban transportation planning model used in many transportation studies, and it is composed of the usual steps of trip generation, trip distribution, modal split, and network assignment. One modification made in TASSIM involves the prediction of transit ridership, which is shared by the modal split and network assignment steps of the model.

In the standard UTP model, automobile trips and transit trips are assigned separately to their respective networks. TASSIM employs a more flexible representation of network assignment and mode choice. The two categories of trips represented are transit trips that are made completely on the transit mode, and other trips that begin as automobile trips. These latter trips can either switch to the transit mode at some point or else continue to their destination on the automobile mode. After the network assignment is completed, the link loadings are adjusted for average automobile occupancy to produce vehicle trips by link.

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[1] Alan M. Voorhees and Associates, Los Angeles Metropolitan Area Mode Choice Model Development Study, Southern California Association of Governments (February 1972).

The emissions submodel forecasts mobile emissions from the transportation activity levels by transforming information on vehicle flows and speeds on each link into contributions to area emissions. The speeds on each link are exogenous. The relations between vehicle speed and emissions per mile in the mode are based on functions compiled by EPA.[1] Emissions on each link are allocated to each zone in proportion to the length of the link that is in each zone. In addition, the cold start emissions are forecast from information on trip productions and vehicle trip ends in each zone. Cold start and running emissions are aggregated into mobile area emissions for each zone.

The general conclusion about the effects of transportation controls as projected by TASSIM have been substantiated by others using similar techniques in the Chicago area and in Washington using disaggregated, direct-demand models.[2]

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[1] U.S. Environmental Protection Agency, Air Pollution Emission Factors, Pub. AP-42, 5th ed. (December 1975).

[2] In Zerbe and Croke's recent study (Richard O. Zerke and Kevin Croke, Urban Transportation for the Environment, Ballinger Publishing Co., Cambridge, Massachusetts, 1975), a "total systems" model is devised for Chicago, utilizing the familiar transportation, emissions, and dispersion models. The authors point out that their method is general enough to analyze many transportation control strategies, as well as specific enough to consider important characteristics of the particular region.

In a recent report by T. Atherton, J. Suhrbier, and W. Jessiman entitled "The Use of Disaggregate Travel Demand Models to Analyze Carpooling Policy Alternatives," Draft Paper, Cambridge, Massachusetts, October 1975 , 3 disaggregate travel demand models are linked together to forecast the changes in VMT that would occur in Washington, D.C. as a result of more than 20 alternative carpool promotion strategies. Forecasted results of an employer based carpool program -- nearly a 2% drop in VMT -- are similar to those as estimated here by TASSIM.

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(2) Analytical Steps: Carpool Program

TASSIM performs a minor role in the evaluation of the direct effect of carpooling since all estimates of changes in automobile occupancy rates are calculated outside of the model. These calculations are based on considerable information regarding the employment and transportation patterns of all four areas as presented in the following tables. (See Figure A-1 for flow chart of analytical steps).

1. Employment and population distribution in three concentric zones was determined. (See Table A-1)

Data were based on the 1970 census reports. Table A-1 suggests that Boston and Washington tend to be similar in employment distributions outside the CBD. Los Angeles is markedly more dispersed than the other three cities.

2. Percent of total trips from residence to workplace was determined. (See Table A-2)

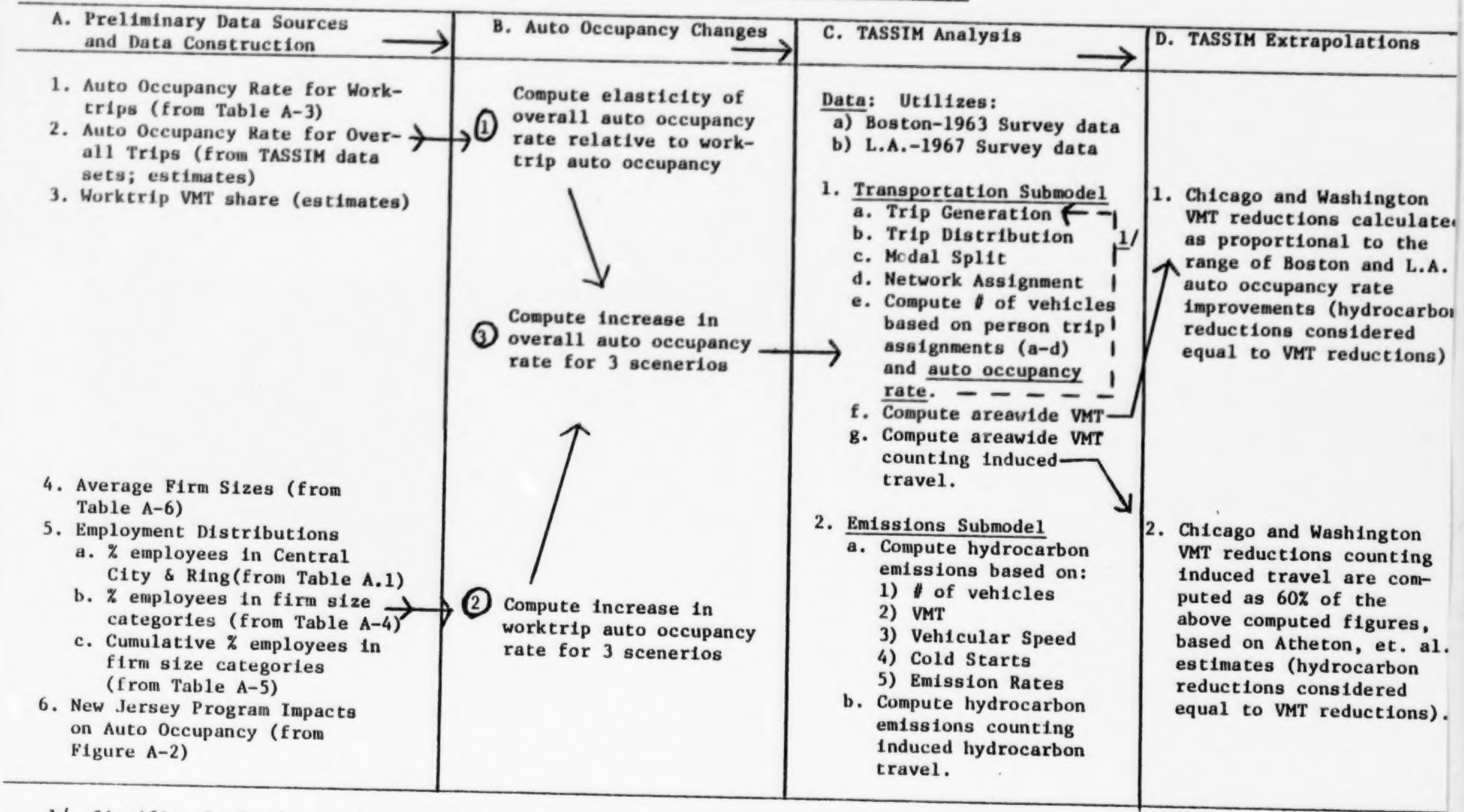
Again, the data were based on the 1970 census. Aggregate trip table were normalized into percentages for comparability. Boston and Washington emerged as somewhat similar, but Chicago had some characteristics akin to Los Angeles' with relatively large ring-to-central-city flows and smaller ring-to-ring flows. In other words, the central city areas of Boston and Washington are small relative to the SMSA while the areas of Los Angeles and Chicago are comparatively large.

3. Worktrip mode split and automobile occupancy by workplace was compiled. (See Table A-3)

Data were drawn from the 1970 Public Use County Group File, which was based on a one percent houshold sample. This file contains records of individual households identified by county of residence and general workplace (CBD, Central City, and Ring). On this file, mode choice is represented by nine choices: auto driver, auto passenger, bus, subway, railroad, taxi, walk, work at home, and other. These were collapsed as shown in Table A-3. Persons per auto is calculated by adding auto drivers to auto passengers and dividing the total by auto drivers.

FIGURE A-1

Flow Chart of Carpool Program Analytical Steps


A. Preliminary Data Sources and Data Construction
B. Auto Occupancy Changes
C. TASSIM Analysis
D. TASSIM Extrapolations
1. Auto Occupancy Rate for Worktrips (from Table A-3)
2. Auto Occupancy Rate for Overall Trips (from TASSIM data sets; estimates)
3. Worktrip VMT share (estimates)
4. Average Firm Sizes (from Table A-6)
5. Employment Distributions
a. % employees in Central City & Ring(from Table A.1)
b. % employees in firm size categories (from Table A-4)
c. Cumulative % employees in firm size categories (from Table A-5)
6. New Jersey Program Impacts on Auto Occupancy (from Figure A-2)
① Compute elasticity of overall auto occupancy rate relative to worktrip auto occupancy
③ Compute increase in overall auto occupancy rate for 3 scenerios
② Compute increase in worktrip auto occupancy rate for 3 scenerios
Data: Utilizes:
a) Boston-1963 Survey data
b) L.A.-1967 Survey data
1. Transportation Submodel
a. Trip Generation
b. Trip Distribution
c. Modal Split
d. Network Assignment
e. Compute # of vehicles based on person trip assignments (a-d) and auto occupancy rate.
1/
f. Compute areawide VMT
g. Compute areawide VMT counting induced travel.
2. Emissions Submodel
a. Compute hydrocarbon emissions based on:
1) # of vehicles
2) VMT
3) Vehicular Speed
4) Cold Starts
5) Emission Rates
b. Compute hydrocarbon emissions counting induced hydrocarbon travel.
1. Chicago and Washington VMT reductions calculate as proportional to the range of Boston and L.A. auto occupancy rate improvements (hydrocarbo reductions considered equal to VMT reductions)
2. Chicago and Washington VMT reductions counting induced travel are computed as 60% of the above computed figures, based on Atheton, et. al. estimates (hydrocarbon reductions considered equal to VMT reductions).

1/ Signifies feedback into the trip generation phase of an increase in auto availability for non-work trips made possible by greater auto occupancy rate. Second run through of model thus includes induced travel, and generates 1.g in C.

TABLE A-1

EMPLOYMENT AND POPULATION DISTRIBUTIONS IN FOUR METROPOLITAN AREAS

Location	Employment			Population		
	Jobs	Percent	Jobs/Sq.Mi.	Persons	Percent	Pop./Sq.Mi.
BOSTON						
CBD	91,000	7.6	91,000	3,700	0.1	3,700
Rest of C.C.	351,000	29.3	7,800	637,000	23.1	13,936
SMSA Other than C.C.	757,000	63.1	804	2,113,000	76.7	2,245
Totals	1,199,000	100.0		2,754,000	100.0	
LOS ANGELES						
CBD	143,000	4.3	51,800	22,150	0.3	8,025
Rest of C.C.	1,446,000	43.9	2,470	3,147,000	44.7	6,180
SMSA Other than C.C.	1,707,000	51.8	400	3,872,000	55.0	1,090
Totals	3,296,000	100.0		7,041,000	100.0	
CHICAGO						
CBD	252,000	8.3	163,000	4,826	0.1	3,113
Rest of C.C.	1,413,000	46.4	4,700	3,364,000	48.2	15,222
SMSA Other than C.C.	1,379,000	45.3	317	3,609,000	51.7	1,032
Totals	3,044,000	100.0		6,978,000	100.0	
WASHINGTON						
CBD	147,000	11.7	106,500	5,105	0.2	3,690
Rest of C.C.	424,000	33.8	7,067	752,000	26.3	12,616
SMSA Other than C.C.	683,000	54.5	300	2,105,000	73.5	920
Totals	1,254,000	100.0		2,862,000	100.0	

Source: Urban Data Book, U.S. Dept. of Transportation, Report No. DOT-TSC-OST-75-45, II. (November 1975)

TABLE A-2

PERCENT OF TOTAL WORKTRIPS FROM RESIDENCE TO WORKPLACE FOR FOUR METROPOLITAN AREAS

Residence Location	Workplace CBD	Non-CBD Central City	Ring	Total
		BOSTON		
Central City	3.0	13.5	4.5	21.0
Ring	4.3	13.3	50.1	67.7
Outside SMSA	0.3	2.5	8.5	11.3
Total	7.6	29.3	63.1	100.0
		LOS ANGELES		
Central City	2.4	28.2	12.2	42.8
Ring	1.8	15.3	37.8	54.9
Outside SMSA	0.2	0.5	1.8	2.5
Total	4.3	43.9	51.8	100.0
		CHICAGO		
Central City	5.3	35.0	7.4	47.7
Ring	3.0	11.0	36.7	50.7
Outside SMSA	0.1	0.5	1.2	1.8
Total	8.3	46.4	45.3	100.0
		WASHINGTON		
Central City	4.7	16.8	4.7	26.2
Ring	6.7	15.6	46.4	68.7
Outside SMSA	0.3	1.4	3.3	5.0
Total	11.7	33.8	54.5	100.0

Source: Urban Data Book, U.S. Dept. of Transportation, Report No. DOT-TSC-OST-75-45.II (November 1975).

TABLE A-3

WORKTRIP MODE SPLIT AND AUTO OCCUPANCY BY WORKPLACE FOR FOUR METROPOLITAN AREAS

Workplace Location	Mode Split (Percent)					Persons Per Auto
	Auto	Transit	Walk	Taxi	Other	
BOSTON						
CBD	36.6	57.4	4.8	0.6	0.6	1.26
Rest of Central City	60.5	25.6	10.7	1.5	1.8	1.23
SMSA Other than C.C.	78.7	7.4	9.4	0.7	3.9	1.20
All	69.6	17.0	9.5	1.0	2.9	1.21
LOS ANGELES						
CBD	75.3	22.2	1.2	0.0	1.3	1.21
Rest of Central City	85.2	6.4	4.4	0.0	3.9	1.11
SMSA Other than C.C.	89.4	2.5	4.2	0.1	3.8	1.11
All	86.8	5.2	4.1	0.1	3.8	1.11
CHICAGO						
CBD	22.5	75.6	1.1	0.5	0.4	1.20
Rest of Central City	59.3	30.3	8.3	0.3	1.9	1.19
SMSA Other than C.C.	84.0	5.8	5.7	0.3	4.1	1.19
All	67.8	22.6	6.5	0.3	2.8	1.19
WASHINGTON						
CBD	57.0	35.4	4.0	1.9	1.3	1.46
Rest of Central City	68.3	22.6	5.0	1.4	2.7	1.26
SMSA Other than C.C.	83.5	5.8	5.2	0.8	4.6	1.16
All	75.3	14.9	5.0	1.2	3.6	1.21

Source: 1970 Census Public Use Data.

The Distribution of Employment by Firm Size

The rate of carpool formation and the availability of employer-based carpool matching programs are likely to vary with firm size, so the distribution of employment by firm size is an important parameter in the evaluation of employer-based carpool programs. Since these data were not available in comparable published form for Boston, Los Angeles, Chicago, and Washington, distributions of employment by firm size had to be estimated from other published data.

These basic data on firm size were derived from the 1973 County Business Patterns which gives firm size data by state, SMSA, county, and industry group. For this paper firm size was estimated for each of seven industry groups: manufacturing, finance, wholesale/retail, construction, services, transportation/communication/public utilities, and other. No data are available in this publication for employees in the public administration category. For each industry group and geographic area the number of firms is given for each of 12 firm size categories, where size is determined by the number of employees. The 12 size categories are: 1-3, 4-7, 8-19, 20-49, 50-99, 100-249, 250-499, 500-999, 1000-1499, 1500-2499, 2500-4999, and 5000 or more. Total employment within each category is also given for the first seven categories (up to 499), and only total employees are reported for firms with 500 or more employees. Thus, it is possible to calculate the average firm size for each of the first seven categories, and this was done by industry group for each metropolitan area. The average firm size for the remaining five categories was estimated by regressing employment in firms over 500 on the number of firms by firm size category. Data at the state level were used, and separate regressions were run for each of the seven industry groups. The resulting average firm sizes are shown in Table A-4. Perhaps of most importance, these regressions provide an estimate of the average firm size in the open-ended category, 5000+.

Having directly calculated average firm size for size categories below 500 and estimated firm sizes in categories above 500, the next step was to estimate the number of employees by firm size category. This was done merely by multiplying the average firm sizes times the number of firms in each size category. For each of the four areas, this calculation was done for the entire SMSA and for the county that contained the SMSA's central city. Employment distributions were still stratified by the seven industry groups. In order to maintain consistency with other data, the firm size distributions were scaled against the employment data given in the 1970 Census.* The 1970 Census reports the total number of workers by industry group and workplace. In order to calculate firm size distributions for the central city and ring in each metropolitan area, the central city employment reported in the 1970 Census was assumed to have the same firm size distribution as the central city's county (calculated with 1973 County Business Patterns data), and the SMSA employment reported in the 1970 Census was assumed to have the same firm size distribution as the SMSA distribution (calculated with the 1973 County Business Patterns data). The employment distribution for the ring was calculated by subtracting the central city employment by firm size category from the SMSA employment by firm size category. The final step was then to add up

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*1970 Journey to Work, Table 2: Characteristics of Workers by Residence and Place of Work for SMSAs of 250,000 or More.

TABLE A-4

ESTIMATED AVERAGE FIRM SIZE FOR FIVE SIZE CATEGORIES AND SEVEN INDUSTRIES

Industry	500-999	1000-1499	Firm Size Category 1500-2499	2500-4999	5000+
Manufacturing	674	1300*	1733	2880	10,300
Finance	576	1382	2208	2948	10,320
Whlsl/Retail	603	1361	1790	3896	9,259
Construction	674	1300*	1733	2880	10,300
Services	675	1308	1884	2996	7,366
T/C/PU	553	1300*	1960	4829	9,620
Other	642	1300*	1909	2740	10,670

Source: Estimated with state-level data from the 1973 County Business Patterns.

*Constrained to equal 1300 because of estimation difficulties.

the employment within each firm size category across the seven industry groups to yield a base for the firm size distributions. These data are shown in Table A-5.

TABLE A-5

EMPLOYMENT BY FIRM SIZE CATEGORY SCALED TO 1970 CENSUS DATA

	BOSTON		LOS ANGELES		CHICAGO		WASHINGTON	
	C.C.	Ring	C.C.	Ring	C.C.	Ring	C.C.	Ring
1-49	115,543	241,687	386,666	813,092	376,260	347,067	112,184	190,684
50-99	42,433	75,796	118,627	246,078	113,716	114,872	36,674	55,533
100-249	57,746	90,856	152,449	311,046	189,755	158,124	45,748	66,330
250-499	40,471	66,286	98,732	209,156	141,713	130,737	35,904	39,696
500-999	32,588	57,286	86,703	169,512	117,163	98,729	20,670	28,581
1000-1499	19,518	33,716	44,521	85,563	70,651	58,345	17,409	23,870
1500-2499	18,778	31,017	35,581	63,337	65,779	51,556	18,889	12,032
2500-4999	16,771	27,612	49,093	87,857	75,188	59,345	25,862	17,876
5000+	24,628	36,158	93,553	173,590	108,165	88,719	10,341	11,205
Total	368,476	660,414	1,065,925	2,159,231	1,278,390	1,107,494	323,681	445,807

Note: Excludes public administration workers.

and the cumulative percentage distributions of employment by firm-size categories.

Before averaging the 7 industrial groups, it was necessary to manipulate the information collected and derived to maintain consistency with other data presented in this study. The 1973 data available and calculated from the County Business Patterns by county and SMSA had to be (a) scaled to 1970 values and (b) placed in a "central city" and "suburban ring" format. The first task entailed the scaling of employment size distributions against the workplace data given in the 1970 Census by industry group for the SMSA, ring, and other areas. The central city firm size distribution was assumed to be identical to the firm size distribution for the county in which the central city was located -- a reasonable assumption for the four roughly "one county" cities analyzed in this study. Since firm size distribution was given for the SMSA, the employment distribution by firm size category for the ring was calculated by subtracting the central city's estimated employment for the SMSA's. After this was completed, employment by firm size category was aggregated over industry groups to yield a base for Table A-6, A-7, and A-8. In addition, the first four firm size categories were aggregated into a single grouping. Note that Table A-6, A-7, and A-8 exclude public administration workers for whom no firm size data are available. Table A-9 shows the significance of public administration workers. Clearly, there may be a bias in the previous firm size estimates for Washington since they were computed without considering a substantial portion of the region's labor force. However, since no alternative was available, the Washington figures in Tables A-6, A-7, and A-8 were utilized in the following analysis, producing potentially biased estimates of automobile occupancy changes in that area.

5. Estimating the percent change in average auto occupancy. (See Table A-10)

The groundwork for this estimation process appears in the top third of Table A-10 under "Basic Data." The overall auto occupancy figures for Boston and Los Angeles are drawn from the same household survey data utilized in the TASSIM model. Chicago and Washington values are essentially estimates based upon the similarity

TABLE A-6

Cumulative Percentage Distributions of Employment By Firm Size Category in Four Metropolitan Areas

Location	Firm Size Category								
	1-49	50-99	100-249	250-499	500-999	1000-1499	1500-2499	2500-4999	5000+
BOSTON									
Central City	31.36	42.87	58.54	69.53	78.37	83.67	88.76	93.32	100.00
Ring	36.60	48.07	61.83	71.87	80.54	85.65	90.34	94.52	100.00
LOS ANGELES									
Central City	36.28	47.40	61.71	70.97	79.10	83.28	86.62	91.22	100.00
Ring	37.66	49.05	63.46	73.15	81.00	84.96	87.89	91.96	100.00
CHICAGO									
Central City	29.43	39.89	54.74	65.82	74.99	80.51	85.66	91.54	100.00
Ring	31.34	41.71	55.99	67.79	76.71	81.98	86.63	91.99	100.00
WASHINGTON									
Central City	34.66	45.99	60.12	71.22	77.60	82.98	88.82	96.81	100.0
Ring	42.77	55.23	70.11	79.01	85.42	90.78	93.48	97.49	100.0

Source: Based on 1973 County Business Patterns and 1970 Census.

Note: Percent distributions exclude workers in public administration category.

TABLE A-7

Percent of Employment by Firm Size in Four Metropolitan Areas

Location	Firm Size Category 1-49	50-99	100-249	250-499	500-999	1000-1499	1500-2499	2500-4999	5,000+
				BOSTON					
Central City	31.36	11.51	15.67	10.99	8.84	5.30	5.09	4.56	6.68
Ring	36.60	11.47	13.76	10.04	8.67	5.11	4.69	4.18	5.48
				LOS ANGELES					
Central City	36.28	11.12	14.31	9.26	8.13	4.18	3.34	4.60	8.78
Ring	37.66	11.39	14.41	9.69	7.85	3.96	2.93	4.07	8.04
				CHICAGO					
Central City	29.43	10.46	14.85	11.08	9.17	5.52	5.15	5.88	8.46
Ring	31.34	10.37	14.28	11.80	8.92	5.27	4.65	5.36	8.01
				WASHINGTON					
Central City	34.66	11.33	14.13	11.10	6.38	5.38	5.84	7.99	3.19
Ring	42.77	12.46	14.88	8.90	6.41	5.36	2.70	4.01	2.51

Source: Based on 1973 County Business Patterns and 1970 Census.

Note: Excludes Public Administration Category.

TABLE A- 8

Average Number of Employees per Firm by Firm Size Category in Four Metropolitan Areas

Area	Firm Size Category 1-49	50-99	100-249	250-499	500-999	1000-1499	1500-2499	2500-4999	5000+
Boston	5.85	61.7	117.9	273.7	510.7	1109.0	1606.3	2773.9	6754.0
Los Angeles	7.07	67.4	150.0	335.8	629.5	1275.3	1766.4	3340.2	9894.2
Chicago	6.91	60.9	137.7	320.9	598.0	1205.6	1607.3	2924.6	9844.2
Washington	7.60	62.3	137.2	312.4	586.3	1290.0	1932.6	3644.8	10773.0

Source: Based on 1973 County Business Patterns and 1970 Census.

Note: Excludes Public Administration Category.

TABLE A- 9

Public Administration Workers as Percent of Total Workforce

Metropolitan Area	Central City	Ring
Boston	8.4	5.1
Los Angeles	6.2	8.2
Chicago	5.5	5.8
Washington	35.9	26.3

Source: 1970 Census.

TABLE A- 10

Percent Change in Persons Per Auto (PPA) For Various Carpool Responses

Item	Boston	Los Angeles	Chicago	Washington
Basic Data				
Average PPA	1.40	1.39	1.4	1.4
Worktrip PPA	1.21	1.11	1.19	1.21
Worktrip Share of VMT	.38	.35	.40	.38
Percent Change in Total PPA for 1% Change in Worktrip PPA	.328	.279	.340	.328
Percent Increase in Worktrip PPA for Various Carpool Responses				
Pessimistic	0.363	0.583	0.599	0.358
Optimistic - 250	6.03	5.72	6.74	5.32
Optimistic - 100	8.10	7.98	8.92	7.97
Percent Increase in Overall PPA for Various Carpool Responses				
Pessimistic	0.119	0.163	0.204	0.117
Optimistic - 250	1.98	1.61	2.29	1.75
Optimistic - 100	2.66	2.23	3.03	2.62

Source: See text for derivation.

of these cities' overall transportation patterns to those of Boston. The worktrip auto occupancy rates are from Table A-3. Worktrip VMT shares are crude approximations, representing total VMT scaled against trip proportion by purpose.[1] The culmination of these adjustments is the elasticity of the total auto occupancy rate relative to worktrip auto occupancy ($\frac{\text{Worktrip Auto Occupancy X Worktrip VMT Share}}{\text{Total Auto Occupancy}}$). These elasticity values are approximately correct for small changes in worktrip occupancy rates.

Underlying these estimates of the worktrip auto occupancy increase is a separate analysis of carpool formation by size of firm based on reports filed with the Region II office of EPA by 45 employers in New Jersey. (See Appendix B). Figure A-2 summarizes the firm size-carpool formation relationship.[2] The most pessimistic of probable impacts from a carpool promotion program is indicated by a line with slope .0005. The most optimistic effects are basically contained within the 15% upper bound. Negative changes were disregarded since they represent other ongoing influences, as discussed in Appendix A. For this analysis it was therefore assumed that the pessimistic change would mean that firms over 250 employees (the minimum firm size for inclusion in the MASSPOOL program) could expect its employees' automobile occupancy rate to increase in percentage terms by $0.0005 \cdot N$ where N is the number of employees in the firm. Optimistic-250 assumes that auto occupancy rates will increase by 15 percent (independent of firm size) for all firms with 250 or more employees. Table A-6 indicates that 250+ firms employ only around 40 percent of the workforce. However, if a program were to include firms with 100 or more employees, it would reach, in almost all instances, greater than 50 percent of the workforce. Therefore, the optimistic-100 scenerio assumes that auto occupancy rates will increase by 15 percent at all firms with 100 or more employees.

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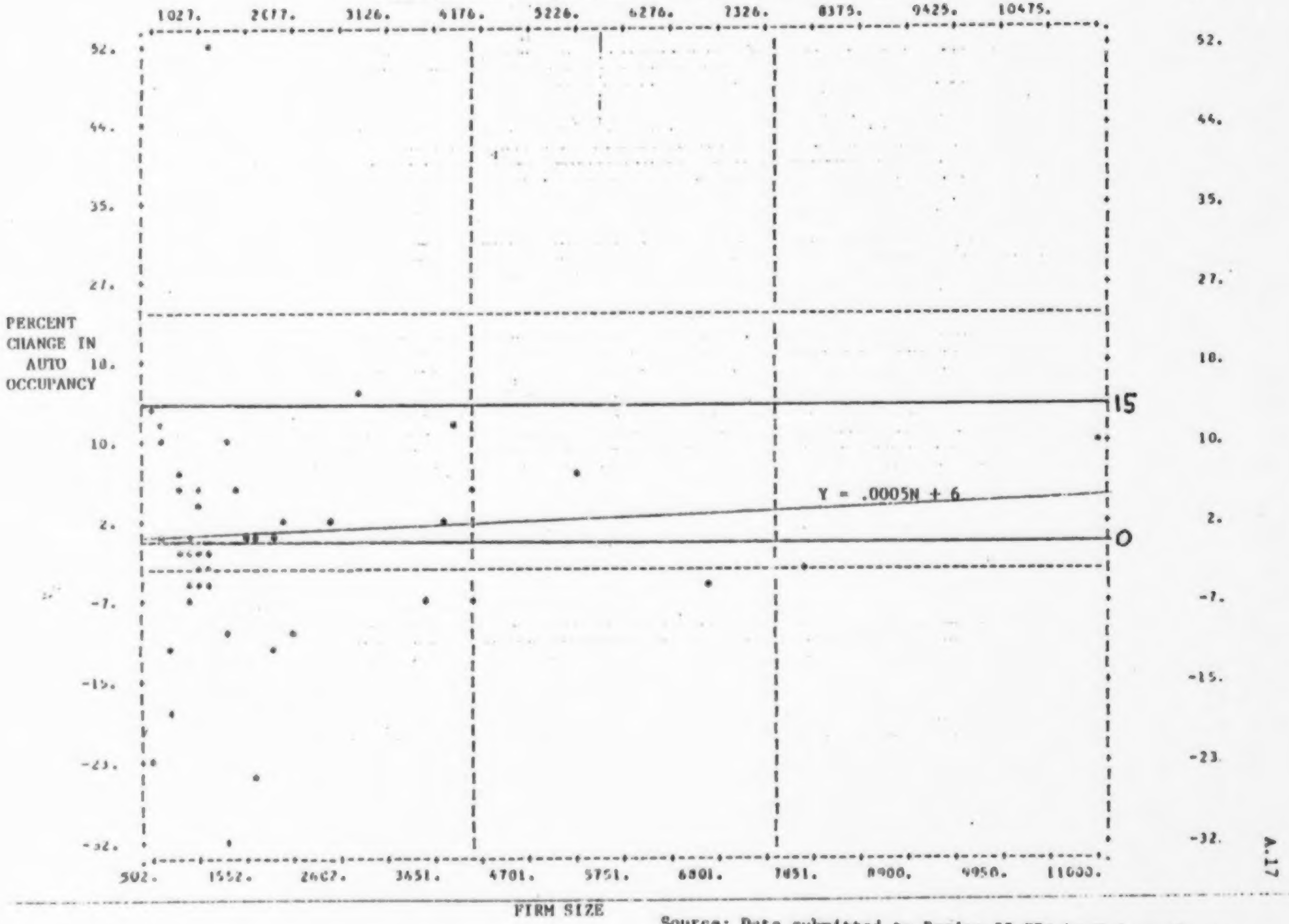
[1] Except for the Washington figure which was estimated by J. Horowitz and L. M. Pernela, "Comparison of Automobile Emissions According to Trip Type in Two Urban Areas." Paper presented at the January 1975 TRB meeting, Washington, D.C.

[2] Although this relationship is not statistically significant, possibly because of incomplete data, it does substantiate the effects of other regional programs as well as indicate the probable validity that the potential for successful carpool matches grows with increasing firm size.

FIGURE A-2
Relationship Between Firm Size and Carpool Formation



Source: Data submitted to Region II EPA by N.J. employers.

The actual percent increases in worktrip auto occupancy were computed as follows, utilizing information from Tables A-6, A- 7and A-8:

$$\text{Pessimistic increases} = \sum_{n=1}^{6}\Big[(.0005X_n)\cdot(\%\ \text{employees in n within Central City})\cdot(\%\ \text{total employees within Central City})\Big] + \sum_{n=1}^{6}\Big[(.0005X_n)\cdot(\%\ \text{employees in n within Ring})\cdot(\%\ \text{total employees in Ring})\Big]$$

where n = Firm size category 250-499, . . . 5000+

X_n = Average firm size in category n.

Optimistic increases were calculated as = 15%·[cumulative % employees in firm size categories 250-499 and above (or 100-249 and above) in Central City]·(% total employees in Central City)

+

15%·[cumulative % employees in 250-499 (or 100-249) and above in Ring]·(% total employees in Ring).

The third section, the percent increase in overall auto occupancy, is merely the product of the worktrip occupancy increases and the respective occupancy elasticities.

6. Percent reduction in areawide VMT produced by various carpooling responses. (See Table A- 11)

Table A-11 reports how the overall change in auto occupancy affects VMT and hydrocarbon emissions in the TASSIM model. The auto occupancy changes are fed into the TASSIM transportation model following the network assignment, where vehicle link loadings are decreased to represent the higher number of person trips per car. The heading marked "induced" represent the extent to which VMT reductions are replaced by non-work travel induced by left-at-home vehicles. TASSIM provides estimates of induced travel for Boston and Los Angeles by feeding back higher values

TABLE A-11

Percent Reduction in Areawide VMT & Mobile Source HC Emissions for Four Metropolitan Areas with Various Carpool Responses

Item	Pessimistic	Optimistic 250	Optimistic 100
BOSTON			
VMT	0.107	1.78	2.39
HC	0.104	1.74	2.34
VMT-Induced	0.063	1.05	1.41
HC-Induced	0.062	1.03	1.38
LOS ANGELES			
VMT	0.149	1.47	2.04
HC	0.147	1.45	2.01
VMT-Induced	0.089	0.88	1.22
HC-Induced	0.088	.87	1.20
CHICAGO			
VMT	0.19	2.2	2.9
HC	0.19	2.2	2.9
VMT-Induced	0.11	1.3	1.7
HC-Induced	0.11	1.3	1.7
WASHINGTON			
VMT	0.11	1.7	2.5
HC	0.11	1.7	2.5
VMT-Induced	0.07	1.00	1.5
HC-Induced	0.07	1.00	1.5

Source: Interpolations of results from TASSIM simulations.

of auto availability into the trip generation model. For Chicago and Washington, 40 percent of the reduction in VMT and hydrocarbon emissions are assumed replaced by induced trips.[1] In Chicago and Washington, VMT and hydrocarbon reductions are assumed to be similar, with their VMT reduction figures calculated as proportional to the range of occupancy rate improvements from Boston and Los Angeles.

(3) Analytical Steps: HOVL Program (See Figure A-3 for flow chart of analytical steps)

7. Percent reduction in areawide VMT produced by transit performance. (See Table A-12)

The hypothetical regional program consists of numerous CBD-directed exclusive buslanes that would reduce average areawide transit vehicle travel time by 20 percent, an estimate based on results from many operating HOVL programs. The estimated effect of HOVL programs on transit travel time is fed directly into the mode choice and network assignment submodels of TASSIM. The Boston and Los Angeles results are based on this TASSIM simulation technique. To develop the extrapolations to the other two cities, the proportion of areawide auto worktrips that are made to the CBD were calculated, using values presented in Table A-2. These proportions are Boston 0.040; Los Angeles 0.038; Chicago 0.028; Washington 0.089. From these proportions, it appeared that the effect in Chicago would be less than Boston and Los Angeles and that the effect in Washington would be greater.

Hydrocarbon emissions, however, will drop less than VMT. Since some of the new transit riders are expected to drive to park-and-ride facilities, vehicular trips will decrease less than VMT. The leakage effect of induced use of left-at-home cars should not be as high as the 40 percent estimate for carpooling, although a 26 percent figure was calculated for the San Bernardino HOVL.[2] Since the TASSIM calculations on HOVL-induced VMT and hydrocarbon reductions assumed that (a) all new bus riders were former automobile users, and (b) that no non-work travel was induced, even these low reduction figures are probably optimistic.

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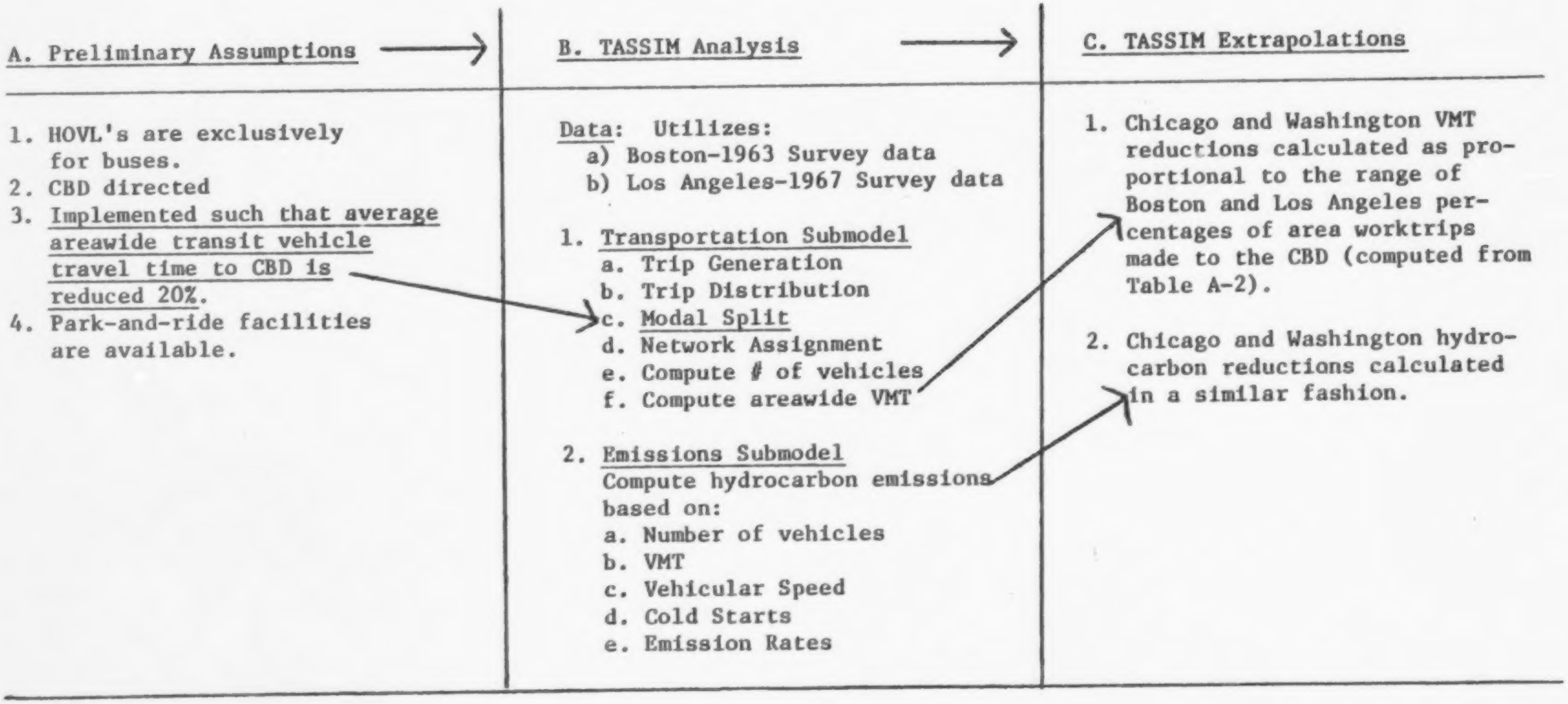
[1] Based on analysis of this induced travel factor presented in T. Atherton, J. Suhrbier, and W. Jessiman.

[2] See San Bernardino Busway discussion in Appendix D.

FIGURE A-3

Flow Chart of HOVL Program Analytic Steps



A. Preliminary Assumptions

1. HOVL's are exclusively for buses.
2. CBD directed
3. Implemented such that average areawide transit vehicle travel time to CBD is reduced 20%.
4. Park-and-ride facilities are available.

B. TASSIM Analysis

Data: Utilizes:
  a) Boston-1963 Survey data
  b) Los Angeles-1967 Survey data

1. Transportation Submodel
   a. Trip Generation
   b. Trip Distribution
   c. Modal Split
   d. Network Assignment
   e. Compute # of vehicles
   f. Compute areawide VMT
2. Emissions Submodel
   Compute hydrocarbon emissions based on:
   a. Number of vehicles
   b. VMT
   c. Vehicular Speed
   d. Cold Starts
   e. Emission Rates

C. TASSIM Extrapolations

1. Chicago and Washington VMT reductions calculated as proportional to the range of Boston and Los Angeles percentages of area worktrips made to the CBD (computed from Table A-2).
2. Chicago and Washington hydrocarbon reductions calculated in a similar fashion.

TABLE A-12

Percent Reduction in Areawide VMT and HC Emissions from Improvements in Transit Performance

(20% Decrease in Travel Time)

Item	Boston	Los Angeles	Chicago	Washington
VMT	0.50	0.62	0.4	1.1
HC Emissions	0.39	0.46	0.3	0.9

Source: TASSIM results and extrapolations of TASSIM results.

(4) Elasticity of Overall Auto Occupancy Rate with Respect to Worktrip Auto Occupancy Rate

Definitions: VMT = vehicle miles traveled
PMT = passenger miles traveled
PPA = persons per auto
w = subscript for worktrips
n = subscript for non-worktrips
t = subscript for total trips
S_n = share of VMT of non-worktrips

1. Suppose PMT_w, PMT_n, and PPA_w, and PPA_n are fixed.

Then $$VMT_w = \frac{PMT_w}{PPA_w} \; ; \quad VMT_n = \frac{PMT_n}{PPA_n} \; ; \; VMT_t = VMT_w + VMT_n \; ; \text{ and}$$

$$PPA_t = \frac{VMT_w}{VMT_t} \cdot PPA_w + \frac{VMT_n}{VMT_t} \cdot PPA_n$$

2. Now, increase PPA_w by multiplying it by $(1+r)$ and designate new quantities with a prime, e.g. VMT', and substitute terms:

$$PPA'_w = PPA_w(1+r) \; ;$$

$$VMT'_w = \frac{PMT_w}{PPA_w\,(1+r)} = \frac{VMT_w}{1+r} \quad ;$$

$$VMT'_t = \frac{VMT_w}{1+r} + VMT_n \; ; \text{ and}$$

$$PPA'_t = \frac{VMT_w \cdot PPA_w}{VMT_w/(1+r) + VMT_n} + \frac{VMT_n \cdot PPA_n}{VMT_w/(1+r) + VMT_n} .$$

Transformation and substitution yields:

$$PPA'_t = \frac{(1+r) \cdot VMT_w \cdot PPA_w}{VMT_w + VMT_n + r \cdot VMT_n} + \frac{(Hr)VMT_n \cdot PPA_n}{VMT_w + VMT_n + r \cdot VMT_n} \; ;$$

and then $$PPA'_t = \frac{(1+r)}{1 + S_n \, . \, r} \cdot PPA_t .$$

3. Further substitution yields the elasticity of PPA_t with respect to PPA_w as:

$$\frac{1}{r}\left[\frac{PPA'_t}{PPA_t} - 1\right] = \frac{1 - S_n}{1 + S_n \cdot r}, \text{ where } r = \frac{\Delta PPA_w}{PPA_w}.$$

Note that this derivation assumes PMT_w, PMT_n, and PPA_n are fixed. For worktrips the fixity of PMT_w is equivalent to assuming that all increases in auto occupancy come from existing auto travelers and no travelers are diverted from other modes. If some of the increased auto ridership comes from other modes such as transit, the reduction in VMT will be overstated.

(5) Regression Data Analysis for N. J. Program Data

Many of the major assumptions concerning impacts of employer carpool programs were derived from results of the 2 1/2 year old New Jersey carpool program. The EPA-promulgated program, described in detail in another Appendix, of this report, calls for mandatory participation of New Jersey employers with 400 or more parking spaces, most of whom are located within the New York City and Philadelphia metropolitan regions, in an effort to increase carpooling (and mass transit use) through promotional and employee matching means. Effects of the program, measured from an August 1973 - March 1974 base-period through January 1976, are presented in Table A-13.

A-13
Table A-13

Impacts of the New Jersey Carpool Program[1/]

Date of Report	Employment	% Carpoolers of Total Employees	# of Car Trips per Employee	VMT per Employee	Average Auto Occupancy
Base (8/73-3/74)	93,195	26%	.720	15.4	1.26
Present (1/76)	89,737	28%	.718	14.9	1.27
Change	-4%		-0.3%	-3.0%	+0.8%

1/ Results based on data from 45 facilities for which January 1976 semi-annual report had been filed (as of April 1976).

Even though the changes noted are minimal, the New Jersey program is the employer carpool program best suited for a brief regression analysis of the determinant factors related to impacts, since any other program is either too recent (MASSPOOL) or too deficient in data [Commuter Club (Washington, D.C.); Commuter Computer (Los Angeles)]. From available data, three sets of independent variables were constructed in order to examine the effects of 1) base-period conditions of the firm, 2) promotional effort, and 3) adjustments in firms' employment levels on the change in the percentage of employees regularly commuting in carpools.

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[1] Data were initially obtained from Region II of EPA, but were subsequently supplemented and verified by telephone contact with the New Jersey employers.

The base period effect consists of five variables which describe (1) the present mode split, a) the number of pre-program carpoolers, b) the number of base period mass trassit users, (2) the pressures for carpooling (parking space/employees ratio), (3) the potential for employee matching (the number of employees), and (4) a proxy for both transit supply and the average commuting distance (firm location). The results of this regression appear in Table A-14.

TABLE A-14

Effect of Base Data Firm Characteristics on Change in Carpoolers - New Jersey

$$\Delta CP = .079 + \underset{(.17)}{.00001FS} + \underset{(.925)}{.203PUBTR} + \underset{(.28)}{.005LOC} - \underset{(8.15)^*}{.417CPINDEX} + \underset{(.71)}{.04PSRATIO}$$

- Figures in parentheses are F-values; * signifies statistical significance to the .01 confidence level. All other variables not significant to the .10 level.
- Sample size is 45 facilities.
- $R^2 = .26$

Variables

Δ CP = Proportional change in number of carpoolers
FS = Base period firm size (number of employees)
PUBTR = Base period proportion of transit users
LOC = Dummy variable (3 = rural; 2 = suburban; 1 = urban)
CPINDEX = Base period proportion of carpoolers.
PSRATIO = Base period number of parking spaces per employee

Only CPINDEX -- the base period proportion of carpoolers -- is significant although the sign and strength of the coeficient is unexpected and misleading. One possible explanation for the value is that the variable is picking up "post energy crisis" effects. That is, when the program took full effect in late 1973, carpooling was at an artificially high level in reaction to the energy crisis. But as its effects weakened, many employees abandoned carpooling to the point that some firms reported negative overall changes in the numbers of carpoolers and in the automobile occupancy rate (see Figure A-1 in Appendix A) at the same time that they were promoting the carpooling concept.

Two other important results appear from this regression run and each is substantiated by findings from a separate regression analysis applied to MASSPOOL base data as shown in Table A-15.

TABLE A-15

Existing Carpool Choice as a Function of Base Data Firm Conditions - Boston Area

$$\begin{array}{llllll} CP = & .137 + & .0092LFS + & .00047W - & .128\ PUBTR - & .03\ SUB \\ & (1.4) & (0.7) & (1.6) & (2.7)^{*} & (1.2) \end{array}$$

- Numbers in parentheses are t-ratios; *indicates significance to the .01 level.
- Sample size is 160 facilities
- $R^2 = .13$

Variables		Sample Mean
CP	= Proportion of work force commuting in multi-occupancy vehicles	0.217
LFS	= Log of firm size (number of employees)	6.44
W	= National average weekly earnings by SIC code (from BLS *Employment and Earnings*, April 1974)	141.00
PUBTR	= Proportion of work force commuting by transit	0.240
SUB	= Dummy variable (1 = suburban location; 0 = central city)	0.519

The first finding is that public transit and carpooling are essentially substitutes, as seen by the negative value of the public transit variable in the MASSPOOL regression, and as suggested by the positive and strong (but still not significant) relationship in New Jersey between base-period transit use and the increase in carpooling about two years later. The implications of this finding are twofold. First, carpool programs will tend to reduce transit patronage in those areas where its use is already heavy, as MASSPOOL planners and transit operators have acknowledged. Secondly, it indicates that carpool programs in suburban areas have been successful, not due to greater matching potential or longer work trips (both are probably CBD advantages) but because of a transit void in those areas that carpooling was able to fill. The second finding is that in neither instance is firm size strongly related to carpooling.

This result is dissappointing since a large employee pool theoretically increases the probability of successful carpool matching. The sign of the firm size variable is, however, positive as expected and is still the best available firm description variable. Although the insignificant firm size coefficients and overall low R_2 values make the use of this variable questionable, the fact that the results predicted by its use closely match those of numerous carpool programs supports its application.

To analyze the effects of promotional effort, a subsample of the 45 Jersey firms was contacted and a proxy variable constructed specifying the degree of firm effort on a 1-3 scale. A value of 3 might indicate a combined program of computer matching, intra-firm advertising, and promotional drive, including contests and prizes. A value of 1 specifies merely the most minimal effort required under TCP regulations. Results from this regression are shown in Table A-16.

TABLE A-16

Effect of Firm Effort on Changes in Carpooling

$$\Delta CP = .10 + \underset{(1.060)}{.05}\ \text{Effort}$$

- Figure in parenthesis is an F-value; variable is not significant.
- Sample size is 11 firms.
- $R^2 = .09$

Despite the non-significance of the coefficient, the sign is expected and indicates the importance of firm policies on the success of carpool programs.

The final regression attempted to test the effects of the 1974-75 business recession on the carpooling program by regressing the change in carpooling on the change in employment over the same period. It was expected that periods of employment loss (over this period, these firms lost 4% of their work force) would prove detrimental to both existing carpools and the potential for successful employee matches. However, regression results were inconclusive since the coefficient was both insignificant and near zero, and the sign was unexpected.

Appendix B: Mode Split and Auto Occupancy Data by Workplace for the 124 Largest SMSAs in the United States

Source: 1970 Census Public Use County Group File (One Percent Sample of Households)

BOSTON

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.29	0.08	0.25	0.27	0.06	0.01	0.05	0.0	788	1.26
CITY	0.49	0.12	0.14	0.09	0.02	0.01	0.11	0.01	3756	1.23
RING	0.67	0.13	0.06	0.01	0.00	0.01	0.09	0.03	6592	1.20
OUT	0.76	0.14	0.02	0.01	0.01	0.01	0.05	0.02	2238	1.18
TOTL	0.61	0.12	0.09	0.05	0.01	0.01	0.09	0.02	13374	1.20

WORCESTE

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.52	0.15	0.24	0.0	0.0	0.0	0.10	0.0	165	1.28
CITY	0.66	0.16	0.06	0.0	0.0	0.00	0.11	0.01	930	1.24
RING	0.70	0.14	0.01	0.0	0.0	0.00	0.10	0.04	377	1.20
OUT	0.69	0.16	0.01	0.0	0.00	0.00	0.10	0.02	819	1.24
TOTL	0.67	0.16	0.05	0.0	0.00	0.00	0.10	0.02	2291	1.24

PROVIDEN

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.61	0.14	0.22	0.0	0.0	0.01	0.03	0.0	190	1.22
CITY	0.70	0.18	0.04	0.0	0.0	0.00	0.06	0.01	1296	1.25
RING	0.75	0.13	0.01	0.0	0.0	0.00	0.08	0.02	965	1.18
OUT	0.73	0.17	0.02	0.00	0.01	0.00	0.04	0.02	299	1.24
TOTL	0.72	0.16	0.04	0.00	0.00	0.00	0.07	0.01	2750	1.22

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                    HARTFORD
         DRIVE      PASS      BUS     SUBWAY     RR      TAXI     WALK     HOME     TOTAL   AUTO OCC
  CBD     0.54      0.15      0.26     0.0      0.0      0.0      0.04     0.01      197      1.27
 CITY     0.65      0.11      0.13     0.0      0.0      0.00     0.09     0.01      996      1.17
 RING     0.77      0.13      0.04     0.0      0.0      0.00     0.05     0.02     1311      1.16
  OUT     0.78      0.16      0.03     0.0      0.0      0.0      0.02     0.01      545      1.21
 TOTL     0.72      0.13      0.08     0.0      0.0      0.00     0.05     0.01     3049      1.18



                    NEW HAVE
         DRIVE      PASS      BUS     SUBWAY     RR      TAXI     WALK     HOME     TOTAL   AUTO OCC
  CBD     0.49      0.19      0.25     0.0      0.0      0.0      0.07     0.01      194      1.38
 CITY     0.69      0.13      0.09     0.00     0.0      0.00     0.07     0.01      937      1.19
 RING     0.72      0.15      0.04     0.0      0.00     0.00     0.05     0.03      770      1.21
  OUT     0.80      0.12      0.02     0.00     0.01     0.00     0.03     0.01      782      1.15
 TOTL     0.72      0.14      0.07     0.00     0.00     0.00     0.05     0.02     2683      1.19



                    SPRINGFI
         DRIVE      PASS      BUS     SUBWAY     RR      TAXI     WALK     HOME     TOTAL   AUTO OCC
  CBD     0.66      0.10      0.20     0.0      0.0      0.0      0.03     0.0        59      1.15
 CITY     0.68      0.14      0.08     0.0      0.0      0.0      0.09     0.01      872      1.21
 RING     0.74      0.15      0.02     0.0      0.0      0.0      0.06     0.03      485      1.21
  OUT     0.79      0.12      0.04     0.0      0.01     0.0      0.03     0.02      172      1.15
 TOTL     0.71      0.14      0.06     0.0      0.00     0.0      0.07     0.02     1588      1.20
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                    ALBANY N
          DRIVE     PASS      BUS     SUBWAY      RR       TAXI      WALK      HOME     TOTAL    AUTO OCC
  CBD     0.59      0.19      0.18     0.0       0.0       0.00      0.04      0.00      205       1.32
 CITY     0.66      0.16      0.07     0.0       0.0       0.01      0.09      0.02     1187       1.25
 RING     0.68      0.14      0.03     0.0       0.0       0.01      0.09      0.05      997       1.21
  OUT     0.69      0.20      0.01     0.0       0.01      0.04      0.05      0.0        83       1.30
 TOTL     0.66      0.16      0.06     0.0       0.00      0.01      0.08      0.03     2472       1.24



                    ROCHESTE
          DRIVE     PASS      BUS     SUBWAY      RR       TAXI      WALK      HOME     TOTAL    AUTO OCC
  CBD     0.54      0.15      0.30     0.0       0.0       0.0       0.01      0.0       306       1.27
 CITY     0.71      0.14      0.08     0.0       0.0       0.00      0.06      0.01     1513       1.20
 RING     0.72      0.14      0.02     0.0       0.0       0.00      0.07      0.05     1287       1.20
  OUT     0.84      0.12      0.01     0.0       0.0       0.0       0.01      0.01       76       1.14
 TOTL     0.70      0.14      0.08     0.0       0.0       0.00      0.06      0.02     3182       1.20



                    SYRACUSE
          DRIVE     PASS      BUS     SUBWAY      RR       TAXI      WALK      HOME     TOTAL    AUTO OCC
  CBD     0.63      0.12      0.22     0.0       0.0       0.01      0.03      0.0       195       1.19
 CITY     0.69      0.12      0.10     0.0       0.0       0.01      0.07      0.02      729       1.18
 RING     0.73      0.12      0.02     0.0       0.0       0.00      0.08      0.05     1047       1.16
  OUT     0.78      0.16      0.01     0.0       0.0       0.0       0.04      0.0        74       1.21
 TOTL     0.71      0.12      0.07     0.0       0.0       0.00      0.07      0.03     2045       1.17
```

UTICA RO

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.59	0.14	0.16	0.0	0.0	0.01	0.10	0.0	104	1.25
CITY	0.69	0.16	0.06	0.0	0.0	0.00	0.07	0.01	509	1.23
RING	0.67	0.15	0.02	0.0	0.0	0.00	0.09	0.08	460	1.22
OUT	0.77	0.17	0.0	0.0	0.0	0.0	0.04	0.02	52	1.22
TOTL	0.68	0.15	0.05	0.0	0.0	0.00	0.08	0.04	1125	1.23

BUFFALO

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.53	0.13	0.30	0.0	0.0	0.01	0.02	0.00	378	1.24
CITY	0.63	0.11	0.16	0.0	0.0	0.00	0.08	0.02	1654	1.17
RING	0.73	0.14	0.04	0.00	0.0	0.00	0.07	0.02	2529	1.19
OUT	0.81	0.09	0.02	0.0	0.0	0.02	0.03	0.03	58	1.11
TOTL	0.68	0.13	0.10	0.00	0.0	0.00	0.07	0.02	4619	1.18

ERIE

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.59	0.14	0.11	0.0	0.0	0.0	0.16	0.0	73	1.23
CITY	0.75	0.11	0.03	0.0	0.0	0.0	0.11	0.01	399	1.14
RING	0.73	0.15	0.01	0.0	0.0	0.0	0.07	0.05	338	1.21
OUT	0.96	0.0	0.0	0.0	0.0	0.0	0.04	0.0	28	1.00
TOTL	0.73	0.12	0.03	0.0	0.0	0.0	0.09	0.02	838	1.17

YOUNGSTO

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.72	0.17	0.06	0.0	0.0	0.0	0.05	0.0	100	1.24
CITY	0.81	0.11	0.02	0.0	0.0	0.00	0.05	0.00	694	1.14
RING	0.30	0.11	0.01	0.0	0.0	0.0	0.04	0.04	748	1.14
OUT	0.83	0.13	0.01	0.0	0.0	0.01	0.03	0.0	182	1.15
TOTL	0.80	0.12	0.02	0.0	0.0	0.00	0.04	0.02	1724	1.14

BINGHMT

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.72	0.13	0.04	0.0	0.0	0.01	0.09	0.01	330	1.18
RING	0.71	0.13	0.02	0.0	0.0	0.00	0.08	0.06	624	1.18
OUT	0.75	0.21	0.0	0.0	0.0	0.0	0.04	0.0	53	1.27
TOTL	0.72	0.13	0.02	0.0	0.0	0.00	0.08	0.04	1007	1.18

WILKES B

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.61	0.16	0.09	0.0	0.0	0.00	0.13	0.01	420	1.27
RING	0.62	0.16	0.04	0.0	0.0	0.01	0.14	0.03	626	1.26
OUT	0.73	0.22	0.03	0.0	0.0	0.0	0.01	0.01	148	1.30
TOTL	0.63	0.17	0.06	0.0	0.0	0.00	0.12	0.02	1194	1.27

NEW YORK

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.08	0.02	0.10	0.62	0.11	0.02	0.05	0.01	8084	1.21
CITY	0.29	0.05	0.15	0.34	0.03	0.01	0.10	0.02	19780	1.17
RING	0.72	0.11	0.05	0.01	0.01	0.01	0.06	0.03	9585	1.16
OUT	0.48	0.10	0.09	0.21	0.05	0.01	0.05	0.01	1857	1.20
TOTL	0.36	0.06	0.11	0.31	0.04	0.01	0.08	0.02	39306	1.17

BRIDGEPO

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.56	0.15	0.21	0.0	0.0	0.01	0.06	0.0	117	1.27
CITY	0.72	0.12	0.06	0.00	0.00	0.00	0.08	0.02	1166	1.16
RING	0.74	0.12	0.03	0.00	0.00	0.00	0.06	0.05	752	1.16
OUT	0.71	0.05	0.01	0.00	0.19	0.00	0.02	0.02	822	1.08
TOTL	0.71	0.10	0.04	0.00	0.05	0.00	0.06	0.03	2857	1.14

JERSEY C

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.38	0.03	0.31	0.0	0.0	0.0	0.28	0.0	29	1.09
CITY	0.43	0.09	0.31	0.01	0.00	0.0	0.16	0.01	529	1.21
RING	0.42	0.10	0.21	0.00	0.00	0.00	0.24	0.01	788	1.24
OUT	0.36	0.10	0.32	0.17	0.03	0.00	0.02	0.00	814	1.28
TOTL	0.40	0.10	0.28	0.07	0.01	0.00	0.14	0.01	2160	1.25

PATERSON

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.57	0.08	0.32	0.0	0.01	0.0	0.03	0.0	76	1.14
CITY	0.67	0.09	0.12	0.0	0.0	0.00	0.10	0.01	792	1.14
RING	0.75	0.11	0.05	0.0	0.00	0.00	0.08	0.02	2691	1.14
OUT	0.58	0.08	0.25	0.03	0.05	0.00	0.01	0.00	1589	1.13
TOTL	0.68	0.09	0.13	0.01	0.02	0.00	0.06	0.01	5148	1.14

NEWARK

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.35	0.07	0.48	0.02	0.05	0.0	0.04	0.0	448	1.19
CITY	0.54	0.09	0.24	0.00	0.00	0.00	0.10	0.02	892	1.16
RING	0.68	0.12	0.08	0.00	0.00	0.00	0.09	0.02	4071	1.17
OUT	0.61	0.07	0.11	0.01	0.19	0.0	0.01	0.00	1298	1.11
TOTL	0.63	0.10	0.13	0.00	0.04	0.00	0.07	0.02	6709	1.16

TRENTON

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.47	0.24	0.23	0.0	0.0	0.01	0.03	0.01	86	1.52
CITY	0.69	0.10	0.07	0.0	0.0	0.0	0.13	0.01	334	1.14
RING	0.74	0.12	0.02	0.0	0.00	0.00	0.08	0.04	449	1.16
OUT	0.71	0.09	0.04	0.0	0.15	0.0	0.01	0.0	185	1.12
TOTL	0.70	0.11	0.06	0.0	0.03	0.00	0.08	0.02	1054	1.16

PHILADEL

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.23	0.05	0.30	0.17	0.18	0.00	0.06	0.01	1069	1.23
CITY	0.50	0.09	0.21	0.07	0.04	0.00	0.08	0.02	6453	1.16
RING	0.72	0.12	0.04	0.01	0.01	0.00	0.06	0.03	7909	1.17
OUT	0.75	0.09	0.05	0.01	0.04	0.01	0.04	0.01	906	1.12
TOTL	0.60	0.10	0.13	0.04	0.03	0.00	0.07	0.02	16337	1.17

WILMINGT

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.55	0.22	0.17	0.0	0.0	0.0	0.06	0.0	120	1.41
CITY	0.72	0.15	0.06	0.0	0.00	0.00	0.05	0.01	464	1.21
RING	0.74	0.15	0.02	0.0	0.0	0.00	0.06	0.03	943	1.20
OUT	0.78	0.13	0.04	0.0	0.03	0.0	0.01	0.01	211	1.16
TOTL	0.73	0.15	0.04	0.0	0.00	0.00	0.05	0.02	1738	1.21

READING

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.45	0.12	0.21	0.0	0.0	0.0	0.21	0.01	73	1.27
CITY	0.68	0.11	0.08	0.0	0.0	0.00	0.11	0.02	402	1.16
RING	0.65	0.14	0.03	0.0	0.0	0.0	0.09	0.08	545	1.22
OUT	0.81	0.09	0.02	0.0	0.01	0.0	0.05	0.01	161	1.11
TOTL	0.67	0.12	0.06	0.0	0.00	0.00	0.10	0.04	1181	1.18

ALLENTOW

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.46	0.30	0.05	0.0	0.0	0.0	0.18	0.0	56	1.65
CITY	0.67	0.16	0.04	0.0	0.0	0.01	0.11	0.02	1013	1.24
RING	0.68	0.13	0.00	0.0	0.0	0.00	0.12	0.07	797	1.19
OUT	0.79	0.12	0.01	0.01	0.00	0.0	0.03	0.03	224	1.15
TOTL	0.68	0.15	0.02	0.00	0.00	0.00	0.10	0.04	2090	1.22

HARRISBU

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.63	0.19	0.09	0.0	0.0	0.00	0.07	0.01	469	1.31
RING	0.70	0.15	0.01	0.0	0.00	0.00	0.10	0.04	950	1.22
OUT	0.76	0.17	0.02	0.0	0.0	0.0	0.03	0.03	116	1.23
TOTL	0.68	0.17	0.03	0.0	0.00	0.00	0.09	0.03	1535	1.24

LANCASTE

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.75	0.11	0.04	0.0	0.0	0.00	0.09	0.01	370	1.14
RING	0.66	0.13	0.01	0.0	0.0	0.00	0.10	0.09	730	1.20
OUT	0.69	0.20	0.0	0.0	0.02	0.01	0.07	0.02	123	1.28
TOTL	0.69	0.13	0.02	0.0	0.00	0.00	0.09	0.06	1223	1.19

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                      YORK
             DRIVE    PASS      BUS    SUBWAY      RR      TAXI     WALK     HOME     TOTAL    AUTO OCC
    CBD      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0         0      1.00
    CITY     0.70     0.18     0.04     0.0      0.0      0.01     0.07     0.01       343      1.26
    RING     0.73     0.12     0.00     0.0      0.00     0.00     0.08     0.07       749      1.16
    OUT      0.75     0.17     0.0      0.0      0.0      0.0      0.05     0.03       126      1.23
    TOTL     0.72     0.14     0.01     0.0      0.00     0.00     0.07     0.05      1218      1.19


                      BALTIMOR
             DRIVE    PASS      BUS    SUBWAY      RR      TAXI     WALK     HOME     TOTAL    AUTO OCC
    CBD      0.44     0.19     0.35     0.0      0.0      0.00     0.02     0.0       443      1.44
    CITY     0.59     0.14     0.18     0.00     0.0      0.01     0.07     0.01      3133      1.23
    RING     0.70     0.16     0.06     0.00     0.0      0.01     0.05     0.03      3336      1.23
    OUT      0.80     0.13     0.01     0.0      0.02     0.0      0.04     0.01       336      1.16
    TOTL     0.64     0.15     0.13     0.00     0.00     0.01     0.06     0.02      7248      1.24


                      WASHINGT
             DRIVE    PASS      BUS    SUBWAY      RR      TAXI     WALK     HOME     TOTAL    AUTO OCC
    CBD      0.40     0.18     0.36     0.0      0.00     0.02     0.04     0.00      1203      1.46
    CITY     0.55     0.14     0.23     0.00     0.00     0.01     0.05     0.01      3542      1.26
    RING     0.74     0.12     0.06     0.0      0.00     0.01     0.03     0.03      5632      1.16
    OUT      0.78     0.11     0.05     0.01     0.01     0.00     0.03     0.01       338      1.14
    TOTL     0.64     0.13     0.15     0.00     0.00     0.01     0.05     0.02     10715      1.21
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                    RICHMOND
        DRIVE       PASS      BUS     SUBWAY     RR      TAXI     WALK     HOME     TOTAL   AUTO OCC
 CBD    0.57        0.18      0.23    0.0        0.0     0.0      0.02     0.0        369     1.32
 CITY   0.68        0.14      0.14    0.0        0.0     0.00     0.04     0.00       981     1.21
 RING   0.73        0.16      0.04    0.0        0.0     0.01     0.02     0.04       481     1.22
  OUT   0.74        0.18      0.04    0.0        0.0     0.0      0.03     0.0         92     1.25
 TOTL   0.67        0.16      0.13    0.0        0.0     0.00     0.03     0.01      1923     1.23
```

```
                    NEWPORT
        DRIVE       PASS      BUS     SUBWAY     RR      TAXI     WALK     HOME     TOTAL   AUTO OCC
 CBD    0.66        0.21      0.11    0.0        0.0     0.0      0.02     0.0        209     1.32
 CITY   0.75        0.12      0.06    0.0        0.0     0.00     0.05     0.01       605     1.16
 RING   0.65        0.22      0.0     0.0        0.0     0.0      0.09     0.04        46     1.33
  OUT   0.65        0.18      0.12    0.01       0.0     0.0      0.03     0.0         98     1.28
 TOTL   0.72        0.15      0.08    0.00       0.0     0.00     0.04     0.01       958     1.21
```

```
                    NORFOLK
        DRIVE       PASS      BUS     SUBWAY     RR      TAXI     WALK     HOME     TOTAL   AUTO OCC
 CBD    0.65        0.15      0.15    0.0        0.0     0.0      0.05     0.01       154     1.23
 CITY   0.71        0.14      0.10    0.0        0.0     0.00     0.04     0.01      1304     1.19
 RING   0.74        0.15      0.04    0.0        0.0     0.00     0.04     0.03       477     1.20
  OUT   0.65        0.20      0.11    0.0        0.0     0.0      0.04     0.0         91     1.31
 TOTL   0.71        0.14      0.09    0.0        0.0     0.00     0.04     0.01      2026     1.20
```

```
                   GREENSBO
         DRIVE     PASS      BUS     SUBWAY     RR      TAXI     WALK     HOME     TOTAL   AUTO OCC
  CBD    0.74      0.20      0.05    0.0        0.0     0.00     0.02     0.0       246     1.27
 CITY    0.74      0.17      0.04    0.0        0.0     0.00     0.04     0.01     1454     1.23
 RING    0.74      0.13      0.02    0.0        0.0     0.00     0.05     0.07      556     1.18
  OUT    0.69      0.22      0.0     0.02       0.0     0.01     0.03     0.04      114     1.32
 TOTL    0.74      0.17      0.03    0.00       0.0     0.00     0.04     0.02     2370     1.22
```

```
                   CHARLOTT
         DRIVE     PASS      BUS     SUBWAY     RR      TAXI     WALK     HOME     TOTAL   AUTO OCC
  CBD    0.71      0.17      0.10    0.0        0.0     0.00     0.01     0.0       203     1.24
 CITY    0.76      0.12      0.07    0.0        0.0     0.00     0.03     0.01      989     1.16
 RING    0.69      0.13      0.01    0.0        0.0     0.01     0.09     0.06      307     1.19
  OUT    0.78      0.18      0.01    0.01       0.0     0.0      0.01     0.0        67     1.23
 TOTL    0.74      0.13      0.06    0.00       0.0     0.01     0.04     0.02     1566     1.18
```

```
                   GREENVIL
         DRIVE     PASS      BUS     SUBWAY     RR      TAXI     WALK     HOME     TOTAL   AUTO OCC
  CBD    0.0       0.0       0.0     0.0        0.0     0.0      0.0      0.0         0     1.00
 CITY    0.78      0.14      0.03    0.0        0.0     0.00     0.04     0.01      474     1.18
 RING    0.74      0.18      0.00    0.0        0.0     0.0      0.05     0.03      552     1.25
  OUT    0.91      0.07      0.0     0.0        0.0     0.0      0.03     0.0        76     1.07
 TOTL    0.77      0.16      0.01    0.0        0.0     0.00     0.04     0.02     1102     1.20
```

COLOMBIA

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.74	0.18	0.03	0.0	0.0	0.01	0.04	0.01	541	1.24
RING	0.71	0.20	0.02	0.0	0.0	0.0	0.06	0.02	432	1.28
OUT	0.84	0.10	0.0	0.0	0.0	0.0	0.04	0.02	50	1.12
TOTL	0.73	0.18	0.02	0.0	0.0	0.00	0.05	0.01	1023	1.25

AUGUSTA

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.69	0.15	0.05	0.0	0.0	0.02	0.08	0.01	314	1.22
RING	0.75	0.17	0.02	0.0	0.0	0.00	0.04	0.02	454	1.22
OUT	0.83	0.14	0.0	0.0	0.0	0.0	0.02	0.0	42	1.17
TOTL	0.73	0.16	0.03	0.0	0.0	0.01	0.06	0.01	810	1.22

CHARLEST

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.64	0.15	0.10	0.0	0.0	0.02	0.08	0.01	411	1.24
RING	0.70	0.19	0.03	0.0	0.0	0.00	0.07	0.01	468	1.27
OUT	0.68	0.21	0.05	0.0	0.0	0.0	0.05	0.0	19	1.31
TOTL	0.67	0.17	0.06	0.0	0.0	0.01	0.07	0.01	898	1.26

JACKONVI

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.66	0.17	0.15	0.0	0.0	0.02	0.01	0.0	131	1.26
CITY	0.75	0.14	0.06	0.0	0.0	0.00	0.03	0.02	1562	1.19
RING	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
OUT	0.66	0.14	0.02	0.0	0.0	0.0	0.16	0.02	56	1.22
TOTL	0.74	0.15	0.06	0.0	0.0	0.01	0.03	0.01	1749	1.20

ORLANDO

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.78	0.11	0.04	0.0	0.0	0.00	0.04	0.02	577	1.14
RING	0.79	0.12	0.02	0.0	0.0	0.01	0.03	0.03	773	1.15
OUT	0.78	0.13	0.06	0.0	0.0	0.0	0.04	0.0	72	1.16
TOTL	0.79	0.12	0.03	0.0	0.0	0.01	0.04	0.02	1422	1.15

FORT LAU

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.78	0.14	0.02	0.0	0.0	0.00	0.03	0.03	930	1.17
RING	0.78	0.12	0.02	0.0	0.0	0.00	0.05	0.02	618	1.16
OUT	0.87	0.10	0.01	0.00	0.0	0.0	0.00	0.02	372	1.11
TOTL	0.80	0.13	0.02	0.00	0.0	0.00	0.03	0.02	1920	1.16

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                  MIAMI
        DRIVE     PASS      BUS     SUBWAY      RR       TAXI      WALK      HOME     TOTAL    AUTO OCC
  CBD   0.58      0.14     0.23     0.0       0.0      0.0       0.03      0.02       189       1.25
 CITY   0.71      0.14     0.10     0.00      0.00     0.00      0.04      0.01      1517       1.20
 RING   0.73      0.14     0.07     0.0       0.0      0.00      0.04      0.02      2609       1.19
  OUT   0.78      0.13     0.04     0.01      0.01     0.01      0.01      0.02       169       1.17
 TOTL   0.72      0.14     0.08     0.00      0.00     0.00      0.04      0.02      4484       1.19


                  TAMPA-ST
        DRIVE     PASS      BUS     SUBWAY      RR       TAXI      WALK      HOME     TOTAL    AUTG OCC
  CBD   0.77      0.17     0.03     0.0       0.0      0.0       0.03      0.01       181       1.22
 CITY   0.80      0.13     0.03     0.0       0.0      0.00      0.03      0.02      1615       1.16
 RING   0.79      0.12     0.01     0.0       0.0      0.00      0.04      0.04      1119       1.15
  OUT   0.88      0.08     0.01     0.0       0.0      0.0       0.03      0.0        106       1.10
 TOTL   0.80      0.12     0.02     0.0       0.0      0.00      0.03      0.02      3021       1.16


                  WEST PAL
        DRIVE     PASS      BUS     SUBWAY      RR       TAXI      WALK      HOME     TOTAL    AUTO OCC
  CBD   0.0       0.0      0.0      0.0       0.0      0.0       0.0       0.0          0       1.00
 CITY   0.79      0.12     0.03     0.0       0.0      0.01      0.04      0.02       341       1.15
 RING   0.77      0.10     0.03     0.0       0.0      0.01      0.06      0.04       776       1.13
  OUT   0.83      0.13     0.04     0.0       0.0      0.0       0.0       0.0         47       1.15
 TOTL   0.77      0.10     0.03     0.0       0.0      0.01      0.05      0.04      1164       1.14
```

ATLANTA

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.65	0.15	0.19	0.0	0.0	0.00	0.00	0.00	516	1.24
CITY	0.70	0.13	0.11	0.0	0.0	0.01	0.03	0.01	2308	1.19
RING	0.80	0.12	0.03	0.0	0.00	0.00	0.02	0.02	2298	1.15
OUT	0.76	0.15	0.05	0.0	0.0	0.03	0.0	0.01	118	1.20
TOTL	0.74	0.13	0.08	0.0	0.00	0.01	0.03	0.01	5240	1.17

BIRMING

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.76	0.14	0.08	0.0	0.0	0.0	0.03	0.0	234	1.18
CITY	0.75	0.13	0.06	0.0	0.0	0.01	0.04	0.01	1186	1.18
RING	0.78	0.12	0.03	0.0	0.0	0.00	0.04	0.02	876	1.15
OUT	0.67	0.19	0.06	0.02	0.0	0.0	0.04	0.02	48	1.28
TOTL	0.76	0.13	0.05	0.00	0.0	0.00	0.04	0.01	2344	1.17

MEMPHIS

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.60	0.14	0.26	0.0	0.0	0.0	0.00	0.0	226	1.23
CITY	0.72	0.14	0.09	0.0	0.0	0.00	0.04	0.01	1616	1.19
RING	0.69	0.14	0.03	0.0	0.0	0.03	0.09	0.02	302	1.20
OUT	0.77	0.14	0.03	0.0	0.0	0.0	0.06	0.0	71	1.18
TOTL	0.71	0.14	0.10	0.0	0.0	0.01	0.04	0.01	2415	1.19

CHATTANO

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.80	0.14	0.03	0.0	0.0	0.01	0.01	0.0	86	1.17
CITY	0.80	0.13	0.02	0.0	0.0	0.01	0.03	0.00	586	1.16
RING	0.72	0.18	0.01	0.0	0.0	0.01	0.04	0.04	280	1.25
OUT	0.82	0.18	0.0	0.0	0.0	0.0	0.0	0.0	38	1.23
TOTL	0.78	0.15	0.02	0.0	0.0	0.01	0.03	0.01	990	1.19

NASHVILL

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.65	0.18	0.13	0.0	0.0	0.00	0.03	0.0	252	1.27
CITY	0.76	0.12	0.06	0.0	0.0	0.00	0.04	0.02	1433	1.16
RING	0.69	0.19	0.0	0.0	0.0	0.01	0.04	0.07	183	1.28
OUT	0.81	0.12	0.0	0.0	0.0	0.0	0.07	0.0	59	1.15
TOTL	0.74	0.13	0.06	0.0	0.0	0.00	0.04	0.02	1927	1.18

KNOXVILL

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.80	0.09	0.10	0.0	0.0	0.01	0.01	0.0	126	1.11
CITY	0.78	0.12	0.04	0.0	0.0	0.00	0.05	0.02	683	1.15
RING	0.79	0.12	0.02	0.0	0.0	0.00	0.03	0.03	458	1.16
OUT	0.77	0.19	0.02	0.0	0.0	0.0	0.0	0.02	53	1.24
TOTL	0.79	0.12	0.03	0.0	0.0	0.00	0.04	0.02	1320	1.15

HUNTING

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.74	0.12	0.03	0.0	0.0	0.01	0.09	0.01	441	1.16
RING	0.76	0.10	0.02	0.0	0.0	0.01	0.08	0.03	226	1.13
OUT	0.87	0.11	0.0	0.0	0.0	0.0	0.0	0.03	38	1.12
TOTL	0.76	0.11	0.03	0.0	0.0	0.01	0.08	0.02	705	1.15

LOUISVIL

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HCME	TOTAL	AUTO OCC
CBD	0.64	0.17	0.15	0.0	0.00	0.00	0.04	0.00	404	1.26
CITY	0.75	0.13	0.07	0.00	0.0	0.00	0.04	0.01	1347	1.17
RING	0.74	0.17	0.03	0.0	0.0	0.00	0.04	0.02	1098	1.23
OUT	0.76	0.14	0.01	0.0	0.0	0.01	0.08	0.0	74	1.18
TOTL	0.73	0.15	0.06	0.00	0.00	0.00	0.04	0.01	2923	1.21

INDIANAP

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.59	0.18	0.20	0.0	0.0	0.00	0.02	0.00	454	1.31
CITY	0.74	0.14	0.05	0.0	0.0	0.00	0.05	0.02	2146	1.18
RING	0.72	0.14	0.04	0.0	0.0	0.0	0.04	0.06	567	1.19
OUT	0.69	0.11	0.01	0.0	0.0	0.00	0.08	0.11	550	1.17
TOTL	0.71	0.14	0.06	0.0	0.0	0.00	0.05	0.04	3717	1.20

CINCINN

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.57	0.17	0.23	0.0	0.0	0.00	0.02	0.00	464	1.30
CITY	0.70	0.13	0.10	0.0	0.0	0.00	0.05	0.02	1835	1.19
RING	0.74	0.13	0.03	0.0	0.0	0.00	0.07	0.03	2215	1.17
OUT	0.82	0.12	0.02	0.0	0.00	0.0	0.02	0.02	255	1.15
TOTL	0.71	0.13	0.08	0.0	0.00	0.00	0.05	0.02	4769	1.19

DAYTON

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.65	0.13	0.17	0.0	0.0	0.0	0.04	0.0	223	1.21
CITY	0.77	0.12	0.06	0.0	0.0	0.00	0.03	0.01	1192	1.15
RING	0.79	0.11	0.01	0.0	0.0	0.00	0.04	0.04	1392	1.14
OUT	0.83	0.10	0.01	0.01	0.0	0.0	0.03	0.02	147	1.12
TOTL	0.77	0.12	0.04	0.00	0.0	0.00	0.04	0.03	2954	1.15

COLOMBUS

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.63	0.12	0.22	0.0	0.0	0.01	0.01	0.00	386	1.19
CITY	0.76	0.12	0.06	0.0	0.0	0.00	0.05	0.01	1776	1.15
RING	0.76	0.10	0.04	0.0	0.0	0.00	0.06	0.04	920	1.14
OUT	0.79	0.13	0.0	0.0	0.01	0.0	0.05	0.01	77	1.16
TOTL	0.74	0.11	0.07	0.0	0.00	0.00	0.05	0.02	3159	1.15

JOHNSTON ,

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.64	0.13	0.11	0.0	0.0	0.0	0.11	0.01	315	1.20
RING	0.60	0.17	0.03	0.0	0.0	0.00	0.13	0.07	445	1.28
OUT	0.74	0.21	0.0	0.0	0.0	0.0	0.04	0.01	72	1.28
TOTL	0.63	0.16	0.06	0.0	0.0	0.00	0.12	0.04	832	1.25

PITTSBUR

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.37	0.12	0.48	0.0	0.01	0.0	0.02	0.0	710	1.33
CITY	0.58	0.10	0.22	0.0	0.00	0.00	0.09	0.01	2138	1.18
RING	0.70	0.12	0.06	0.0	0.00	0.00	0.09	0.02	4882	1.16
OUT	0.84	0.10	0.02	0.0	0.0	0.0	0.04	0.00	215	1.12
TOTL	0.64	0.11	0.14	0.0	0.00	0.00	0.08	0.02	7945	1.18

AKRON

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.69	0.18	0.09	0.0	0.0	0.0	0.03	0.01	148	1.26
CITY	0.79	0.13	0.02	0.0	0.0	0.00	0.05	0.01	916	1.17
RING	0.77	0.13	0.00	0.0	0.0	0.00	0.06	0.03	829	1.17
OUT	0.86	0.11	0.01	0.0	0.0	0.00	0.01	0.01	416	1.13
TOTL	0.79	0.13	0.01	0.0	0.0	0.00	0.05	0.02	2309	1.17

CANTON

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.75	0.15	0.07	0.0	0.0	0.0	0.03	0.0	88	1.20
CITY	0.76	0.14	0.04	0.0	0.0	0.0	0.05	0.01	429	1.19
RING	0.74	0.15	0.01	0.0	0.0	0.00	0.06	0.04	605	1.20
OUT	0.88	0.09	0.0	0.0	0.0	0.0	0.01	0.01	144	1.10
TOTL	0.76	0.14	0.02	0.0	0.0	0.00	0.05	0.02	1266	1.19

CLEVELAN

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.42	0.10	0.43	0.03	0.00	0.0	0.02	0.00	660	1.24
CITY	0.68	0.10	0.16	0.01	0.00	0.00	0.05	0.01	3076	1.15
RING	0.75	0.12	0.05	0.00	0.0	0.00	0.06	0.03	3256	1.15
OUT	0.83	0.09	0.01	0.00	0.00	0.00	0.05	0.00	256	1.11
TOTL	0.69	0.11	0.13	0.01	0.00	0.00	0.05	0.01	7248	1.15

LORAIN-E

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.78	0.13	0.00	0.0	0.00	0.01	0.07	0.01	453	1.17
RING	0.79	0.08	0.0	0.0	0.0	0.0	0.05	0.08	192	1.10
OUT	0.83	0.10	0.04	0.0	0.0	0.0	0.01	0.02	162	1.12
TOTL	0.79	0.11	0.01	0.0	0.00	0.00	0.05	0.03	807	1.14

TOLEDO

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.65	0.15	0.18	0.0	0.0	0.01	0.01	0.0	180	1.23
CITY	0.79	0.11	0.03	0.0	0.0	0.00	0.05	0.02	1308	1.14
RING	0.78	0.10	0.01	0.0	0.0	0.00	0.06	0.04	735	1.13
OUT	0.87	0.12	0.0	0.0	0.0	0.0	0.01	0.01	163	1.13
TOTL	0.78	0.11	0.03	0.0	0.0	0.00	0.05	0.02	2386	1.14

DETROIT

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.52	0.10	0.36	0.0	0.01	0.00	0.02	0.0	794	1.19
CITY	0.72	0.11	0.12	0.0	0.00	0.00	0.04	0.01	4400	1.15
RING	0.81	0.11	0.03	0.0	0.00	0.00	0.03	0.02	8397	1.14
OUT	0.81	0.13	0.01	0.0	0.0	0.00	0.04	0.01	336	1.16
TOTL	0.76	0.11	0.08	0.0	0.00	0.00	0.04	0.01	13927	1.14

FLINT

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.70	0.14	0.07	0.0	0.0	0.01	0.08	0.0	128	1.20
CITY	0.81	0.14	0.01	0.0	0.0	0.00	0.03	0.00	820	1.17
RING	0.82	0.11	0.00	0.0	0.0	0.0	0.04	0.03	526	1.14
OUT	0.75	0.21	0.0	0.0	0.0	0.0	0.02	0.02	96	1.28
TOTL	0.80	0.13	0.01	0.0	0.0	0.00	0.04	0.01	1570	1.17

GRAND R

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.67	0.17	0.10	0.0	0.0	0.0	0.04	0.01	139	1.26
CITY	0.79	0.12	0.02	0.0	0.0	0.01	0.05	0.02	730	1.15
RING	0.79	0.12	0.00	0.0	0.0	0.00	0.05	0.03	859	1.15
OUT	0.90	0.07	0.0	0.0	0.01	0.0	0.01	0.01	86	1.08
TOTL	0.79	0.12	0.02	0.0	0.00	0.00	0.05	0.02	1814	1.15

LANSING

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.72	0.20	0.04	0.0	0.0	0.0	0.04	0.0	97	1.27
CITY	0.78	0.14	0.02	0.0	0.0	0.00	0.05	0.01	626	1.17
RING	0.73	0.11	0.0	0.0	0.0	0.0	0.08	0.07	469	1.15
OUT	0.78	0.12	0.0	0.0	0.0	0.0	0.08	0.02	59	1.15
TOTL	0.76	0.13	0.01	0.0	0.0	0.00	0.06	0.03	1251	1.17

FORT WAY

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.70	0.14	0.12	0.0	0.0	0.0	0.05	0.0	151	1.20
CITY	0.82	0.11	0.02	0.0	0.0	0.0	0.04	0.01	596	1.13
RING	0.78	0.12	0.0	0.0	0.0	0.0	0.04	0.06	248	1.15
OUT	0.77	0.08	0.04	0.0	0.0	0.0	0.08	0.04	26	1.10
TOTL	0.79	0.11	0.03	0.0	0.0	0.0	0.04	0.02	1021	1.14

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                  SOUTH BE
         DRIVE    PASS     BUS     SUBWAY     RR      TAXI     WALK     HOME     TOTAL   AUTO OCC
  CBD    0.67     0.18     0.13    0.0        0.0     0.0      0.03     0.0        96     1.27
 CITY    0.75     0.13     0.04    0.0        0.0     0.01     0.04     0.01      415     1.17
 RING    0.73     0.13     0.02    0.0        0.0     0.01     0.08     0.05      346     1.18
  OUT    0.84     0.13     0.01    0.01       0.0     0.0      0.01     0.01      129     1.16
 TOTL    0.75     0.13     0.03    0.00       0.0     0.01     0.05     0.02      986     1.18


                  CHICAGO
         DRIVE    PASS     BUS     SUBWAY     RR      TAXI     WALK     HCME     TOTAL   AUTO OCC
  CBD    0.19     0.04     0.25    0.25       0.26    0.01     0.01     0.00     2081     1.20
 CITY    0.50     0.10     0.22    0.05       0.04    0.00     0.08     0.01    1C989     1.19
 RING    0.72     0.14     0.04    0.01       0.01    0.00     0.06     0.02    11386     1.19
  OUT    0.71     0.11     0.05    0.04       0.03    0.01     0.04     0.01      512     1.16
 TOTL    0.58     0.11     0.14    0.05       0.04    0.00     0.07     0.02    24968     1.19


                  GARY
         DRIVE    PASS     BUS     SUBWAY     RR      TAXI     WALK     HCME     TOTAL   AUTO OCC
  CBD    0.60     0.17     0.19    0.0        0.0     0.0      0.03     0.01      109     1.29
 CITY    0.72     0.12     0.07    0.0        0.00    0.00     0.07     0.01     1177     1.16
 RING    0.72     0.15     0.02    0.0        0.0     0.00     0.07     0.04      532     1.21
  OUT    0.68     0.11     0.05    0.0        0.13    0.01     0.02     0.01      282     1.16
 TOTL    0.71     0.13     0.06    0.0        0.02    0.00     0.06     0.02     2100     1.18
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PEORIA

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.66	0.18	0.13	0.0	0.0	0.0	0.04	0.0	102	1.27
CITY	0.71	0.16	0.05	0.0	0.0	0.0	0.05	0.03	442	1.23
RING	0.72	0.16	0.01	0.0	0.0	0.00	0.06	0.04	618	1.22
OUT	0.76	0.13	0.0	0.0	0.0	0.0	0.08	0.03	38	1.17
TOTL	0.71	0.16	0.03	0.0	0.0	0.00	0.06	0.03	1200	1.22

DAVENPOR

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.74	0.14	0.04	0.0	0.0	0.00	0.06	0.01	705	1.19
RING	0.71	0.15	0.00	0.0	0.00	0.0	0.04	0.09	474	1.20
OUT	0.64	0.31	0.03	0.0	0.0	0.0	0.03	0.0	39	1.48
TOTL	0.73	0.15	0.03	0.0	0.00	0.00	0.05	0.04	1218	1.20

ROCKFORD

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.68	0.16	0.11	0.0	0.0	0.0	0.05	0.0	62	1.24
CITY	0.78	0.14	0.03	0.0	0.0	0.0	0.05	0.01	649	1.18
RING	0.76	0.13	0.01	0.0	0.0	0.0	0.05	0.05	276	1.17
OUT	0.71	0.26	0.03	0.0	0.0	0.0	0.0	0.0	38	1.37
TOTL	0.76	0.14	0.03	0.0	0.0	0.0	0.05	0.02	1025	1.19

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                         MADISON
            DRIVE      PASS       BUS      SUBWAY      RR        TAXI      WALK      HOME      TOTAL     AUTO OCC
    CBD     0.62       0.11       0.17     0.0         0.0       0.03      0.07      0.0        175       1.19
    CITY    0.65       0.13       0.07     0.0         0.0       0.00      0.13      0.03       643       1.20
    RING    0.62       0.14       0.01     0.0         0.0       0.00      0.08      0.14       241       1.23
     OUT    0.82       0.08       0.0      0.0         0.0       0.0       0.06      0.04        49       1.10
    TOTL    0.64       0.13       0.07     0.0         0.0       0.01      0.11      0.05      1108       1.20



                         MILWAUKE
            DRIVE      PASS       BUS      SUBWAY      RR        TAXI      WALK      HOME      TOTAL     AUTO OCC
    CBD     0.47       0.14       0.36     0.0         0.00      0.0       0.02      0.00       442       1.29
    CITY    0.66       0.11       0.13     0.00        0.00      0.00      0.08      0.02      2468       1.16
    RING    0.71       0.13       0.05     0.00        0.0       0.00      0.07      0.04      2209       1.18
     OUT    0.68       0.13       0.08     0.0         0.02      0.0       0.06      0.04       103       1.19
    TOTL    0.67       0.12       0.12     0.00        0.00      0.00      0.07      0.03      5222       1.18



                         APPLETON
            DRIVE      PASS       BUS      SUBWAY      RR        TAXI      WALK      HOME      TOTAL     AUTO OCC
    CBD     0.0        0.0        0.0      0.0         0.0       0.0       0.0       0.0          0       1.00
    CITY    0.75       0.12       0.03     0.0         0.0       0.00      0.08      0.02       421       1.16
    RING    0.68       0.10       0.0      0.0         0.0       0.00      0.13      0.09       493       1.15
     OUT    0.84       0.04       0.02     0.0         0.0       0.0       0.10      0.0         49       1.05
    TOTL    0.72       0.11       0.01     0.0         0.0       0.00      0.11      0.05       963       1.15
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DULUTH

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.66	0.16	0.08	0.0	0.0	0.0	0.10	0.0	119	1.24
CITY	0.70	0.12	0.04	0.0	0.0	0.00	0.11	0.03	341	1.17
RING	0.70	0.10	0.02	0.0	0.0	0.00	0.15	0.03	304	1.14
OUT	0.68	0.18	0.11	0.0	0.0	0.0	0.04	0.0	28	1.26
TOTL	0.69	0.12	0.04	0.0	0.0	0.00	0.12	0.02	792	1.17

MINNEAPO

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.51	0.17	0.29	0.0	0.0	0.00	0.02	0.00	807	1.34
CITY	0.69	0.12	0.10	0.0	0.0	0.00	0.07	0.02	3133	1.18
RING	0.76	0.13	0.02	0.0	0.0	0.00	0.06	0.03	2754	1.17
OUT	0.76	0.11	0.05	0.0	0.0	0.0	0.04	0.04	102	1.14
TOTL	0.70	0.13	0.09	0.0	0.0	0.00	0.06	0.02	6796	1.19

DESMOIN

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.66	0.22	0.07	0.0	0.0	0.0	0.04	0.00	247	1.34
CITY	0.76	0.11	0.03	0.0	0.0	0.00	0.05	0.05	637	1.15
RING	0.77	0.11	0.02	0.0	0.0	0.0	0.04	0.07	179	1.14
OUT	0.78	0.17	0.0	0.0	0.0	0.0	0.04	0.0	23	1.22
TOTL	0.74	0.14	0.03	0.0	0.0	0.00	0.05	0.04	1086	1.19

OMAHA

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.62	0.14	0.19	0.0	0.0	0.01	0.03	0.01	278	1.23
CITY	0.72	0.14	0.06	0.0	0.0	0.00	0.05	0.02	1075	1.20
RING	0.70	0.13	0.05	0.0	0.0	0.00	0.08	0.04	512	1.19
OUT	0.84	0.05	0.05	0.0	0.0	0.0	0.05	0.0	37	1.06
TOTL	0.70	0.14	0.08	0.0	0.0	0.00	0.06	0.02	1902	1.20

WICHITA

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.81	0.09	0.06	0.0	0.0	0.00	0.04	0.0	218	1.11
CITY	0.78	0.12	0.01	0.0	0.0	0.00	0.05	0.04	761	1.15
RING	0.79	0.15	0.0	0.0	0.0	0.0	0.03	0.04	391	1.19
OUT	0.70	0.11	0.04	0.0	0.0	0.0	0.11	0.04	27	1.16
TOTL	0.79	0.12	0.01	0.0	0.0	0.00	0.04	0.03	1397	1.15

KANSAS C

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.57	0.21	0.19	0.0	0.0	0.0	0.02	0.01	356	1.37
CITY	0.73	0.15	0.07	0.0	0.0	0.00	0.03	0.02	2234	1.20
RING	0.76	0.16	0.02	0.0	0.0	0.00	0.04	0.03	1964	1.21
OUT	0.72	0.12	0.09	0.0	0.0	0.03	0.04	0.0	100	1.17
TOTL	0.73	0.16	0.06	0.0	0.0	0.00	0.03	0.02	4654	1.21

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                ST LOUIS
          DR'VE     PASS      BUS     SUBWAY     RR       TAXI      WALK      HOME     TOTAL    AUTO OCC
   CBD    0.52      0.18      0.29    0.0        0.0      0.0       0.01      0.0       325      1.35
  CITY    0.67      0.16      0.12    0.0        0.00     0.01      0.04      0.01     2919      1.24
  RING    0.77      0.14      0.03    0.00       0.0      0.01      0.04      0.03     4506      1.18
   OUT    0.79      0.06      0.04    0.0        0.0      0.01      0.07      0.03      112      1.08
  TOTL    0.72      0.15      0.07    0.00       0.00     0.01      0.04      0.02     7862      1.20


                LITTLE R
          DRIVE     PASS      BUS     SUBWAY     RR       TAXI      WALK      HOME     TOTAL    AUTO OCC
   CBD    0.76      0.14      0.06    0.0        0.0      0.01      0.03      0.0       110      1.18
  CITY    0.78      0.13      0.04    0.0        0.0      0.00      0.04      0.02      758      1.16
  RING    0.76      0.08      0.04    0.0        0.0      0.0       0.06      0.06      160      1.11
   OUT    0.85      0.12      0.04    0.0        0.0      0.0       0.0       0.0        26      1.14
  TOTL    0.77      0.12      0.04    0.0        0.0      0.00      0.04      0.02     1054      1.15


                TULSA
          DRIVE     PASS      BUS     SUBWAY     RR       TAXI      WALK      HOME     TOTAL    AUTO OCC
   CBD    0.76      0.17      0.04    0.0        0.0      0.01      0.03      0.0       267      1.22
  CITY    0.81      0.12      0.01    0.0        0.0      0.00      0.04      0.01     1058      1.15
  RING    0.79      0.10      0.0     0.0        0.0      0.01      0.07      0.04      356      1.13
   OUT    0.78      0.07      0.02    0.02       0.0      0.0       0.06      0.06       54      1.10
  TOTL    0.80      0.12      0.02    0.00       0.0      0.00      0.04      0.02     1735      1.15
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OKLAHOMA

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.71	0.20	0.04	0.0	0.0	0.01	0.02	0.0	161	1.29
CITY	0.83	0.12	0.01	0.0	0.0	0.00	0.03	0.02	1629	1.14
RING	0.79	0.10	0.00	0.0	0.0	0.0	0.06	0.05	488	1.13
OUT	0.75	0.16	0.02	0.0	0.0	0.0	0.07	0.0	44	1.21
TOTL	0.81	0.12	0.01	0.0	0.0	0.00	0.03	0.02	2322	1.15

DALLAS

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.63	0.17	0.20	0.0	0.0	0.0	0.01	0.0	606	1.27
CITY	0.78	0.12	0.06	0.0	0.0	0.00	0.02	0.02	3443	1.15
RING	0.80	0.11	0.02	0.0	0.0	0.00	0.03	0.04	1685	1.14
OUT	0.85	0.11	0.01	0.0	0.0	0.0	0.02	0.01	178	1.13
TOTL	0.77	0.12	0.06	0.0	0.0	0.00	0.02	0.02	5912	1.16

FORT WOR

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.71	0.19	0.08	0.0	0.0	0.0	0.01	0.0	160	1.27
CITY	0.79	0.14	0.02	0.0	0.0	0.00	0.03	0.02	1268	1.18
RING	0.81	0.15	0.00	0.0	0.0	0.0	0.02	0.02	1126	1.10
OUT	0.84	0.15	0.01	0.0	0.0	0.0	0.0	0.0	309	1.17
TOTL	0.80	0.15	0.02	0.0	0.0	0.00	0.02	0.02	2863	1.18

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AUSTIN

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.75	0.10	0.12	0.0	0.0	0.0	0.02	0.0	126	1.14
CITY	0.75	0.14	0.03	0.0	0.0	0.01	0.04	0.03	738	1.19
RING	0.78	0.08	0.01	0.0	0.0	0.0	0.07	0.07	103	1.10
OUT	0.74	0.23	0.0	0.0	0.0	0.0	0.03	0.0	39	1.31
TOTL	0.76	0.13	0.04	0.0	0.0	0.00	0.04	0.03	1006	1.18

SHREVEPO

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.70	0.11	0.17	0.0	0.0	0.01	0.01	0.0	76	1.15
CITY	0.78	0.11	0.05	0.0	0.0	0.0	0.04	0.02	555	1.14
RING	0.74	0.11	0.02	0.0	0.0	0.0	0.11	0.03	259	1.15
OUT	0.77	0.09	0.09	0.0	0.0	0.0	0.05	0.0	44	1.12
TOTL	0.76	0.11	0.05	0.0	0.0	0.00	0.06	0.02	934	1.14

JACKSON

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.86	0.07	0.03	0.0	0.0	0.01	0.03	0.0	131	1.08
CITY	0.74	0.15	0.03	0.0	0.0	0.01	0.05	0.02	496	1.20
RING	0.71	0.20	0.0	0.0	0.0	0.0	0.07	0.02	164	1.28
OUT	0.83	0.14	0.0	0.0	0.0	0.03	0.0	0.0	35	1.17
TOTL	0.76	0.15	0.02	0.0	0.0	0.01	0.05	0.02	826	1.19

MOBILE

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.77	0.14	0.04	0.0	0.0	0.01	0.03	0.0	71	1.18
CITY	0.77	0.15	0.03	0.00	0.0	0.01	0.03	0.01	692	1.19
RING	0.71	0.17	0.01	0.0	0.0	0.0	0.06	0.04	339	1.24
OUT	0.63	0.34	0.02	0.0	0.0	0.0	0.01	0.0	80	1.54
TOTL	0.75	0.17	0.03	0.00	0.0	0.01	0.04	0.02	1182	1.22

BATCN RO

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.84	0.11	0.05	0.0	0.0	0.0	0.0	0.0	57	1.13
CITY	0.78	0.12	0.04	0.0	0.0	0.00	0.04	0.02	561	1.15
RING	0.76	0.15	0.01	0.0	0.0	0.01	0.05	0.03	144	1.19
OUT	0.79	0.17	0.03	0.0	0.0	0.0	0.0	0.01	71	1.21
TOTL	0.78	0.13	0.04	0.0	0.0	0.00	0.03	0.02	833	1.16

NEW ORLE

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.47	0.11	0.40	0.0	0.0	0.00	0.02	0.0	613	1.22
CITY	0.57	0.11	0.24	0.0	0.0	0.01	0.05	0.02	1456	1.20
RING	0.71	0.14	0.07	0.0	0.0	0.01	0.04	0.02	1004	1.20
OUT	0.79	0.14	0.04	0.0	0.0	0.01	0.02	0.0	95	1.17
TOTL	0.60	0.12	0.21	0.0	0.0	0.01	0.04	0.01	3168	1.20

BEAUMONT

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.76	0.18	0.04	0.0	0.0	0.0	0.02	0.0	49	1.24
CITY	0.76	0.15	0.03	0.0	0.0	0.01	0.04	0.01	700	1.20
RING	0.76	0.20	0.01	0.0	0.0	0.0	0.02	0.01	230	1.26
OUT	0.93	0.0	0.0	0.0	0.0	0.0	0.07	0.0	28	1.00
TOTL	0.76	0.16	0.02	0.0	0.0	0.00	0.04	0.01	1007	1.21

HOUSTON

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.67	0.17	0.13	0.0	0.0	0.00	0.01	0.01	922	1.26
CITY	0.78	0.13	0.05	0.0	0.0	0.00	0.03	0.02	4286	1.16
RING	0.80	0.12	0.01	0.0	0.0	0.00	0.04	0.04	1700	1.15
OUT	0.77	0.13	0.01	0.0	0.0	0.01	0.07	0.02	118	1.16
TOTL	0.77	0.13	0.05	0.0	0.0	0.00	0.03	0.02	7026	1.17

SAN ANTO

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.64	0.16	0.17	0.0	0.0	0.0	0.02	0.0	284	1.25
CITY	0.76	0.14	0.05	0.0	0.0	0.00	0.03	0.02	1528	1.19
RING	0.76	0.15	0.01	0.0	0.0	0.00	0.03	0.05	487	1.20
OUT	0.62	0.26	0.06	0.0	0.0	0.0	0.04	0.02	53	1.42
TOTL	0.75	0.15	0.06	0.0	0.0	0.00	0.03	0.02	2752	1.20

CORPUS C

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.92	0.04	0.03	0.0	0.0	0.0	0.01	0.0	73	1.04
CITY	0.83	0.11	0.02	0.0	0.0	0.00	0.02	0.03	519	1.13
RING	0.73	0.14	0.00	0.0	0.0	0.00	0.07	0.05	243	1.19
OUT	0.77	0.19	0.0	0.0	0.0	0.0	0.0	0.03	31	1.25
TOTL	0.81	0.12	0.01	0.0	0.0	0.00	0.03	0.03	866	1.14

ELPASO

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.69	0.12	0.13	0.0	0.0	0.0	0.06	0.01	104	1.17
CITY	0.74	0.13	0.07	0.00	0.0	0.01	0.04	0.02	797	1.17
RING	0.77	0.10	0.02	0.0	0.0	0.01	0.10	0.0	134	1.13
OUT	0.62	0.14	0.21	0.0	0.0	0.0	0.02	0.0	42	1.23
TOTL	0.73	0.12	0.08	0.00	0.0	0.00	0.05	0.02	1077	1.17

ALBUQUER

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.83	0.06	0.08	0.0	0.0	0.0	0.03	0.0	102	1.07
CITY	0.83	0.08	0.01	0.0	0.0	0.00	0.05	0.03	743	1.10
RING	0.85	0.11	0.01	0.0	0.0	0.0	0.03	0.01	143	1.13
OUT	0.82	0.05	0.0	0.0	0.0	0.0	0.09	0.05	22	1.06
TOTL	0.83	0.08	0.02	0.0	0.0	0.00	0.05	0.02	1010	1.10

DENVER

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.62	0.15	0.17	0.0	0.0	0.00	0.05	0.00	383	1.25
CITY	0.79	0.10	0.04	0.0	0.00	0.00	0.05	0.02	2212	1.13
RING	0.82	0.08	0.01	0.0	0.0	0.00	0.04	0.04	1791	1.10
OUT	0.73	0.15	0.01	0.0	0.0	0.0	0.08	0.03	75	1.20
TOTL	0.79	0.10	0.04	0.0	0.00	0.00	0.05	0.03	4461	1.13

SALT LAK

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.66	0.16	0.09	0.0	0.0	0.0	0.08	0.01	172	1.25
CITY	0.79	0.12	0.03	0.0	0.0	0.00	0.05	0.02	930	1.15
RING	0.79	0.13	0.01	0.0	0.00	0.00	0.04	0.04	742	1.16
OUT	0.67	0.26	0.01	0.0	0.0	0.01	0.04	0.01	96	1.39
TOTL	0.77	0.13	0.02	0.0	0.00	0.00	0.05	0.02	1940	1.17

SPOKANE

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.66	0.14	0.13	0.0	0.0	0.0	0.06	0.02	143	1.21
CITY	0.78	0.09	0.02	0.0	0.0	0.0	0.08	0.03	487	1.11
RING	0.83	0.06	0.01	0.0	0.0	0.0	0.06	0.04	257	1.07
OUT	0.93	0.07	0.0	0.0	0.0	0.0	0.0	0.0	15	1.07
TOTL	0.78	0.09	0.03	0.0	0.0	0.0	0.07	0.03	902	1.11

SEATTLE

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.52	0.15	0.29	0.0	0.0	0.00	0.04	0.0	370	1.30
CITY	0.74	0.11	0.09	0.0	0.0	0.00	0.04	0.02	2767	1.15
RING	0.81	0.10	0.01	0.00	0.0	0.00	0.04	0.04	1720	1.12
OUT	0.80	0.12	0.05	0.0	0.0	0.01	0.03	0.0	110	1.15
TOTL	0.75	0.11	0.07	0.00	0.0	0.00	0.04	0.03	4967	1.15

TACOMA

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.59	0.19	0.17	0.01	0.0	0.01	0.03	0.0	90	1.32
CITY	0.83	0.09	0.03	0.0	0.0	0.0	0.04	0.01	496	1.11
RING	0.80	0.11	0.01	0.0	0.0	0.0	0.05	0.03	441	1.14
OUT	0.82	0.15	0.02	0.0	0.0	0.0	0.01	0.0	155	1.19
TOTL	0.80	0.12	0.03	0.00	0.0	0.00	0.04	0.02	1182	1.15

PORTLAND

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.50	0.17	0.28	0.0	0.0	0.00	0.05	0.0	294	1.35
CITY	0.77	0.10	0.06	0.0	0.0	0.00	0.05	0.02	1698	1.13
RING	0.79	0.09	0.02	0.0	0.0	0.00	0.04	0.05	1472	1.12
OUT	0.76	0.08	0.04	0.0	0.0	0.0	0.08	0.04	84	1.11
TOTL	0.76	0.10	0.06	0.0	0.0	0.00	0.05	0.03	3548	1.13

LAS VEGA

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.85	0.09	0.02	0.0	0.0	0.0	0.03	0.01	433	1.11
RING	0.83	0.10	0.04	0.0	0.0	0.00	0.03	0.01	463	1.11
OUT	0.57	0.17	0.23	0.0	0.0	0.0	0.02	0.02	53	1.30
TOTL	0.82	0.10	0.04	0.0	0.0	0.00	0.03	0.01	949	1.12

PHCENIX

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.82	0.13	0.03	0.0	0.0	0.0	0.02	0.0	200	1.15
CITY	0.83	0.10	0.01	0.0	0.0	0.00	0.03	0.02	1935	1.12
RING	0.81	0.10	0.00	0.00	0.0	0.00	0.05	0.03	1044	1.13
OUT	0.83	0.15	0.0	0.02	0.0	0.0	0.0	0.0	48	1.17
TOTL	0.83	0.10	0.01	0.00	0.0	0.00	0.04	0.02	3227	1.13

TUSCON

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.86	0.11	0.02	0.0	0.0	0.0	0.02	0.0	56	1.13
CITY	0.82	0.11	0.01	0.0	0.0	0.0	0.03	0.03	776	1.13
RING	0.75	0.10	0.01	0.0	0.0	0.0	0.10	0.04	180	1.13
OUT	0.67	0.14	0.14	0.0	0.0	0.0	0.03	0.03	36	1.21
TOTL	0.80	0.11	0.02	0.0	0.0	0.0	0.04	0.03	1048	1.13

SAN DIEG

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.76	0.10	0.09	0.0	0.0	0.0	0.04	0.01	216	1.13
CITY	0.82	0.09	0.03	0.0	0.0	0.00	0.04	0.02	2148	1.11
RING	0.79	0.11	0.01	0.0	0.0	0.0	0.05	0.04	1617	1.14
OUT	0.86	0.04	0.01	0.0	0.0	0.01	0.07	0.01	85	1.04
TOTL	0.81	0.10	0.03	0.0	0.0	0.00	0.04	0.02	4066	1.12

LOS ANGE

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.63	0.13	0.22	0.00	0.0	0.0	0.01	0.00	1055	1.21
CITY	0.78	0.08	0.07	0.0	0.0	0.00	0.04	0.02	11005	1.11
RING	0.82	0.09	0.03	0.0	0.00	0.00	0.04	0.02	11711	1.11
OUT	0.84	0.10	0.03	0.00	0.0	0.00	0.02	0.00	755	1.12
TOTL	0.80	0.09	0.05	0.00	0.00	0.00	0.04	0.02	24526	1.11

ANAHEIM

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.93	0.04	0.0	0.0	0.0	0.01	0.02	0.0	114	1.05
CITY	0.86	0.09	0.00	0.0	0.0	0.00	0.02	0.03	1328	1.10
RING	0.83	0.09	0.00	0.0	0.0	0.00	0.05	0.02	2212	1.10
OUT	0.92	0.06	0.00	0.0	0.0	0.00	0.01	0.00	1250	1.07
TOTL	0.87	0.08	0.00	0.0	0.0	0.00	0.03	0.02	4904	1.09

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                BAKERSFI
        DRIVE   PASS    BUS    SUBWAY   RR     TAXI    WALK    HOME    TOTAL   AUTO OCC
 CBD    0.0     0.0     0.0    0.0      0.0    0.0     0.0     0.0        0     1.00
 CITY   0.89    0.06    0.01   0.0      0.0    0.00    0.03    0.01     354     1.07
 RING   0.83    0.09    0.01   0.0      0.0    0.0     0.04    0.03     570     1.11
  OUT   0.77    0.10    0.0    0.0      0.0    0.0     0.03    0.10      31     1.13
 TOTL   0.85    0.08    0.01   0.0      0.0    0.00    0.04    0.02     955     1.10


                FRESNO
        DRIVE   PASS    BUS    SUBWAY   RR     TAXI    WALK    HCME    TOTAL   AUTO OCC
 CBD    0.83    0.11    0.04   0.0      0.0    0.0     0.0     0.01      89     1.14
 CITY   0.86    0.08    0.02   0.0      0.0    0.0     0.03    0.01     573     1.09
 RING   0.74    0.11    0.01   0.0      0.0    0.0     0.07    0.08     516     1.15
  OUT   0.89    0.07    0.02   0.0      0.0    0.0     0.0     0.02      46     1.07
 TOTL   0.81    0.09    0.01   0.0      0.0    0.0     0.04    0.04    1224     1.12


                OXNARD
        DRIVE   PASS    BUS    SUBWAY   RR     TAXI    WALK    HOME    TOTAL   AUTO OCC
 CBD    0.0     0.0     0.0    0.0      0.0    0.0     0.0     0.0        0     1.00
 CITY   0.81    0.09    0.02   0.0      0.0    0.0     0.06    0.01     390     1.12
 RING   0.81    0.10    0.01   0.0      0.0    0.0     0.05    0.03     534     1.13
  OUT   0.89    0.09    0.0    0.0      0.0    0.0     0.01    0.00     238     1.10
 TOTL   0.83    0.10    0.01   0.0      0.0    0.0     0.04    0.02    1162     1.12
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SAN BERN

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.85	0.09	0.01	0.0	0.0	0.00	0.04	0.01	1104	1.10
RING	0.81	0.09	0.00	0.0	0.00	0.00	0.06	0.03	1921	1.11
OUT	0.89	0.09	0.01	0.0	0.0	0.0	0.01	0.0	379	1.10
TOTL	0.84	0.09	0.01	0.0	0.00	0.00	0.05	0.02	3404	1.11

SANTA BA

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.74	0.12	0.03	0.0	0.0	0.0	0.08	0.03	302	1.16
RING	0.83	0.08	0.00	0.0	0.0	0.0	0.06	0.03	490	1.10
OUT	0.87	0.07	0.0	0.0	0.0	0.0	0.07	0.0	30	1.08
TOTL	0.80	0.09	0.01	0.0	0.0	0.0	0.07	0.03	822	1.12

STOCKTON

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.84	0.09	0.02	0.0	0.00	0.0	0.04	0.01	407	1.11
RING	0.76	0.11	0.01	0.0	0.0	0.0	0.05	0.08	397	1.15
OUT	0.96	0.04	0.0	0.0	0.0	0.0	0.0	0.0	49	1.04
TOTL	0.81	0.10	0.01	0.0	0.00	0.0	0.04	0.04	853	1.12

SACRAMEN

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.75	0.11	0.09	0.0	0.0	0.01	0.04	0.0	157	1.14
CITY	0.81	0.12	0.04	0.0	0.0	0.00	0.03	0.01	1286	1.15
RING	0.81	0.08	0.00	0.0	0.0	0.0	0.05	0.05	1053	1.10
OUT	0.89	0.06	0.02	0.0	0.0	0.0	0.01	0.01	93	1.07
TOTL	0.81	0.10	0.03	0.0	0.0	0.00	0.04	0.02	2589	1.13

SALINAS

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	1.00
CITY	0.83	0.09	0.02	0.0	0.0	0.0	0.06	0.01	323	1.10
RING	0.75	0.14	0.01	0.0	0.0	0.01	0.06	0.02	374	1.19
OUT	0.79	0.09	0.03	0.0	0.0	0.0	0.03	0.06	33	1.12
TOTL	0.79	0.12	0.02	0.0	0.0	0.00	0.06	0.02	730	1.15

SAN FRAN

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.36	0.10	0.45	0.00	0.03	0.00	0.07	0.00	1570	1.28
CITY	0.63	0.09	0.19	0.0	0.01	0.00	0.07	0.02	3749	1.14
RING	0.79	0.09	0.03	0.0	0.00	0.00	0.05	0.03	5305	1.12
OUT	0.84	0.07	0.04	0.0	0.00	0.01	0.04	0.01	477	1.08
TOTL	0.68	0.09	0.14	0.00	0.01	0.00	0.04	0.02	11101	1.13

SAN JOSE

	DRIVE	PASS	BUS	SUBWAY	RR	TAXI	WALK	HOME	TOTAL	AUTO OCC
CBD	0.74	0.12	0.04	0.0	0.0	0.0	0.10	0.01	104	1.16
CITY	0.85	0.08	0.01	0.0	0.0	0.0	0.03	0.03	1075	1.10
RING	0.86	0.08	0.00	0.0	0.00	0.0	0.03	0.03	2016	1.09
OUT	0.80	0.08	0.03	0.0	0.08	0.0	0.01	0.00	460	1.10
TOTL	0.84	0.08	0.01	0.0	0.01	0.0	0.03	0.03	3655	1.10

PART B: CITY AND CASE STUDY RESULTS

CHAPTER 2: Summaries of Case Study and City Report Results

(1) Introduction

The objective of this section of the report is to provide an estimate of the probable effectiveness, costs, and benefits of promoting (1) carpool and vanpool programs and (2) high-occupancy vehicle lanes (HOVLs) to reduce oxident levels in the atmosphere derived from the case and city study experiences. The research for this section was performed in two interrelated phases:

I. Technical literature describing applications of the strategies was reviewed and contact was made with individuals who had operated or evaluated existing projects. Factors contributing to the success or failure of projects were identified and evaluated; and, when the data base seemed appropriate, a detailed statistical analysis was performed. From this effort, a series of policy-oriented conclusions were formulated to summarize the applicability of these emission control strategies under different urban conditions.

II. As experience in evaluating programs was gained, the emphasis of the study shifted to examining the application of the strategies in four cities -- Boston, Washington, D.C ., Chicago, and Los Angeles. On the basis of direct program observation, descriptive data, empirical analyses, and extensive contact with program administrators as well as affected groups, conclusions were made on the probable efffectiveness of the strategies in reducing hydrocarbon emissions in the test cities and in urban regions in general. (This study focuses on the control of hydrocarbon emissions since they are widely assumed to play an integral role in the formation of photochemical oxidants.)[1]

Case and City Study Organization Outline

As a prelude to this Chapter and Appendicies C and D which present descriptions of the estimated effectiveness of the strategies, the remainder of this chapter contains two parts: (a) the methodology of the research is described in more detail, and (b) a series of tables summarize the empirical data collected on specific projects and cities. In Chapter , the general outline and estimated cost and benefit effectiveness of carpool and vanpool programs are presented first assuming that most readers will be interested primarily in this policy issue. Second, the future prospects and overall applicability of the strategy under different circumstances is examined. In Chapter on HOVLs, the same format is repeated.

All detailed explanations, reports, and analyses have been placed in the appendices. Appendix A, Sections 1 - 4 contains a description of TASSIM, the simulation model used to estimate the probable adjustments in hydrocarbon emission levels due to each strategy under different assumptions. Appendix A, Section 5 describes the regression analysis of carpool-formation data from two regional carpool programs that provided critical coefficients for TASSIM and considerable understanding for evaluating the general applicability of carpool matiching programs. Appencix C presents information from extensive interviews and program reports collected in the four case-study cities. The final three appendices include the general review of literature as well as detailed observation of selected examples of carpool, vanpool, and HOVL programs across the country; Volume 2; "Analysis of

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[1] For a discussion of the connection between hydrocarbon emissions and photochemical oxidants, see U.S. EPA, Office of Air and Waste Management, Control of Photochemical Oxidants - Technical Basis and Implications of Recent Findings, Research Trianble Park, N.C. (1975); Volume 2; "Analysis of Errors Associated with Relating Hydrocarbon Emission Control to Oxidant Reduction" - 1976-Bentz, et al; A Brief Survey of Air Data Base, and Ambient Air Models" - 1975-Bentz, Galvis

(2) Bases of City Selection

General Rationale

The four cities receiving detailed study in this report were selected to provide a profile of urban characteristics that could be extrapolated to all urban areas faced with vehicular pollution problems. Choice was also influenced by the availability of appropriate data. Boston, Washington, D.C., Chicago, and Los Angeles fulfilled these requirements. At the same time, all four cities have acknowledged having a serious oxidant problem and have given Level I priority to the reduction of hydrocarbon emissions in their respective State Implementation Plans (SIPs).[1]

Transportation Control Plans

The Transportation Control Plans (TCPs) for all four cities, except Chicago's, mandate a regional carpool matching program, and some type of employer-based matching programs has been organized in these regions. These three areas (Boston, Washington, D.C., and Los Angeles) also are required to implement HOVLs on major freeways and arterials where feasible.

The TCP presently in effect for Chicago does not include any provisions for a carpool matching program, although such a strategy is listed among the possible alternative actions. No new HOVL programs are mandated either; but the U.S. Environmental Protection Agency has provided strong support to the City's plans for (1) a CBD contra-flow bus lane project and (2) the feasibility study of possible HOVL designs in the Southeast commuter corridor. All four cities have placed stress on vehicle inspection/maintenance strategies but these approaches are facing delays and political resistance in each city.

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[1] Environmental Reporter, Sec. 121, "EPA Regulations on Approval and Promulgation of Implementation Plans" (1975).

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Economic and Demographic Characteristics

Economically and demographically, the four cities can be characterized as "variations on a theme," the theme being the occurrence of overall regional economic and population growth but with residential and commercial distribution increasingly based on the mobility provided by the automobile. Spurred by strong financial support and demands provided by widespread automobile ownership, freeway systems have dominated the growth of the transportation system in the last decade while transit operations have steadily lost riders.

Beyond this generalization, however, the four cities possess sets of unique characteristics. Sizes differ (see Table 2.1). Since the transporation and economic infrastructures of each city were constructed during different historical periods, each responded dissimilarly to growth pressures. The population of both the Boston and Washington, D.C. SMSAs is close to the average of 2,445,000 persons for the nation's 33 largest SMSAs, but they are below the 3,200 square mile average land area. By contrast, both Chicago and Los Angeles have populations significantly higher than the national average although the land areas are only slightly larger. In addition, the cities of Los Angeles/Long Beach and Chicago are above average in their share of their SMSA's population and area, while the reverse holds true for the relatively small, older cities of Washington, D.C. and Boston.

Table 2-1

General Economic Information on Four Sample SMSA Areas

	Population 1/2/ 1970 (000's)	Δ 2/ 1960-70	Land 2/ Area (Sq.Mi)	Empl'mt 1/ 1970 (000's)	Large Firm 3/ Empl't Distrb	Retail Sales 1/4/ 1972 (billion)
Boston SMSA	2,899	+7.9%	1,288	1,199	---	$ 7.1
Central City	641(22%)	-8.1%	47(4%)	442(37%)	39%	1.87(26%)
Outside C.C.	2,258(78%)	+13.0%	1,241(96%)	757(63%)	61%	5.23(74%)
Washington, D.C. SMSA	2,909	+37.9%	2,812	1,254	---	$ 7.5
Central City	757(26%)	-1.0%	61(2%)	571(46%)	53%	1.80(24%)
Outside C.C.	2,152(74%)	+60.0%	2,751(98%)	683(54%)	47%	5.7(76%)
Chicago SMSA	6,979	+12.2%	3,719	3,044	---	$17.0
Central City	3,367(48%)	-5.2%	221(6%)	1,665(55%)	55%	7.5(44%)
Outside C.C.	3.612(52%)	+35.3%	3,498(94%)	1,379(45%)	45%	9.5(56%)
Los Angeles/	7,032	+16.4%	4,069	3,296	---	$17.0
Long Beach SMSA 5/	3,175(45%)	+12.5%	455(11%)	1,589(48%)	49%	6.9(41%)
Central City	3,857(55%)	+20.0%	3,614(89%)	1,707(52%)	51%	10.1(59%)
Outside C.C.						
NATION'S SMSAs:Total 6/	80,678	+16.9%	106,249	27,801	---	----
Central City	34,697(43%)	-1.4%	4,633(4.4%)	14,806(53%)	---	----
Outside C.C.	45,987(57%)	+36.8%	101,616(95.6%)	12,995(47%)	---	----

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1/ Percent in these columns represent the portion of the SMSA totals attributable to the Central City and suburban areas.

2/ Source: 1970 Census of Population, Vol.I.

3/ Source: 1973 County Business Patterns and 1970 Census. Distribution was based on private employees only, which includes roughly 90% of the region's job force except for Washington, D.C. SMSA, where 36% of the Central City and 26% of the suburban employees are public administration workers (as of 1970).

4/ Source: 1972 Census of Retail Trade: Area Statistics.

5/ Central City figures include both Los Angeles and Long Beach.

6/ Date is for 33 largest SMSA's taken from Urban Transportation Fact Book, American Institute of Planners, Motor Vehicle Manufacturers Association of U.S., Inc. (March 1974).

Commuting Patterns

The role of transit for work-trips offers another set of contrasts (see Table 2.2). The majority of work-trips to the dense urban cores of Chicago and Boston are handled by rail and bus transit. This fact is important for both carpool and HOVL programs since both carpools and new express bus routes have been shown to attract riders from existing transit.[1] The importance of transit drops quickly from CBD to suburban areas in all four cities, with relatively little difference in modal split among the four SMSA's for areas outside the central city. These suburban locations also have the lowest automobile occupancy rates which, when coupled with the high automobile use, shows that the potential for carpool formation is highest in these areas.

Highway Development

Each example city has developed a highway network that serves its particular economic and physical circumstances. As illustrated on the accompanying maps, the high capacity freeway system serving the Los Angeles region is unique in its lack of (a) predominant convergence on one CBD area, and (b) directional peaking. On most of that area's freeways, traffic volumes, even in rush hours, are relatively equal in both directions — a situation that makes the contra-flow HOVLs which favor one direction of

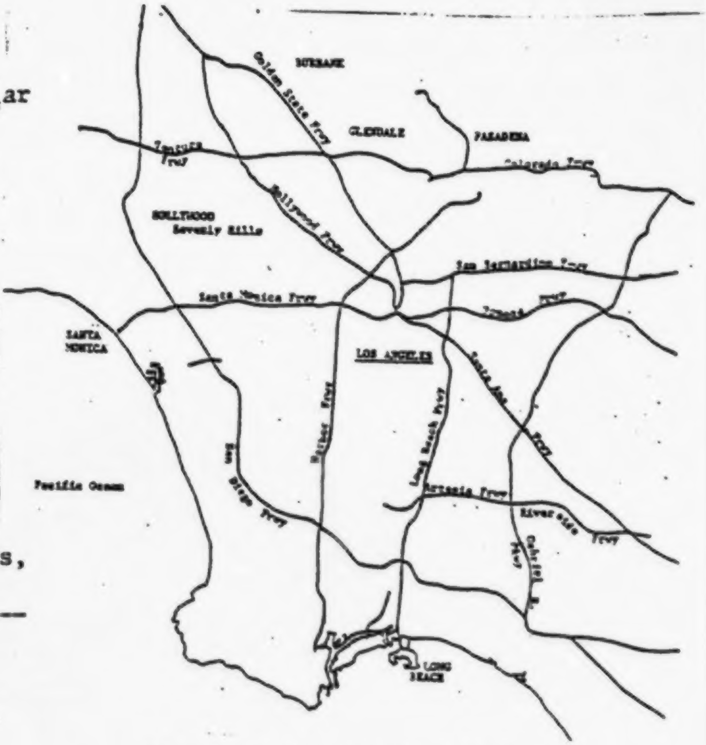

Fig. 2.1: Los Angeles Area

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[1] This point is discussed in detail in Chapter 2.

Table 2.2

WORKTRIP MODE SPLIT AND AUTO OCCUPANCY BY WORKPLACE FOR FOUR METROPOLITAN AREAS

Workplace Location	Mode Split (Percent) Auto	Transit	Walk	Taxi	Other	Persons Per Auto
BOSTON						
CBD	36.6	57.4	4.8	0.6	0.6	1.26
Rest of Central City	60.5	25.6	10.7	1.5	1.8	1.23
SMSA Other than C.C.	78.7	7.4	9.4	0.7	3.9	1.20
All	69.6	17.0	9.5	1.0	2.9	1.21
LOS ANGELES						
CBD	75.3	22.2	1.2	0.0	1.3	1.21
Rest of Central City	85.2	6.4	4.4	0.0	3.9	1.11
SMSA Other than C.C.	89.4	2.5	4.2	0.1	3.8	1.11
All	86.8	5.2	4.1	0.1	3.8	1.11
CHICAGO						
CBD	22.5	75.6	1.1	0.5	0.4	1.20
Rest of Central City	59.3	30.3	8.3	0.3	1.9	1.19
SMSA Other than C.C.	84.0	5.8	5.7	0.3	4.1	1.19
All	67.8	22.6	6.5	0.3	2.8	1.19
WASHINGTON						
CBD	57.0	35.4	4.0	1.9	1.3	1.46
Rest of Central City	68.3	22.6	5.0	1.4	2.7	1.26
SMSA Other than C.C.	83.5	5.8	5.2	0.8	4.6	1.16
All	75.3	14.9	5.0	1.2	3.6	1.21

Source: 1970 Census Public Use Data.

travel impossible. Chicago's dependence on transit enables it to have a relatively low-density of freeways. Although these tend to converge at the CBD, the majority of the CBD-terminating freeways in Chicago also have rail transit lines operating in their medians, a factor that removes them from HOVL consideration due to the fear that expanded carpool and express bus use in those corridors will hurt existing transit ridership.

Superficially, the highway networks to Washington, D.C. and Boston appear to be strongly oriented to the CBD. In both cases, the configuration is dominated by one or more beltways with radial expressways feeding away from the CBD like the spokes of a wheel. The Boston area, however, has a number of corridors that presently are not served effectively by commuter rail service and also has freeways or major arterials that are suitable for HOVL system development if coupled with expanded express bus service. A disproportionately large number of the Washington, D.C. region's expressways enter the District's CBD due to the inner city's (1) important role in tourism, (2) political significance, and (3) high density employment. This CBD-oriented network of freeways makes an extensive HOVL program possible, especially in the absence of commuter rail lines.

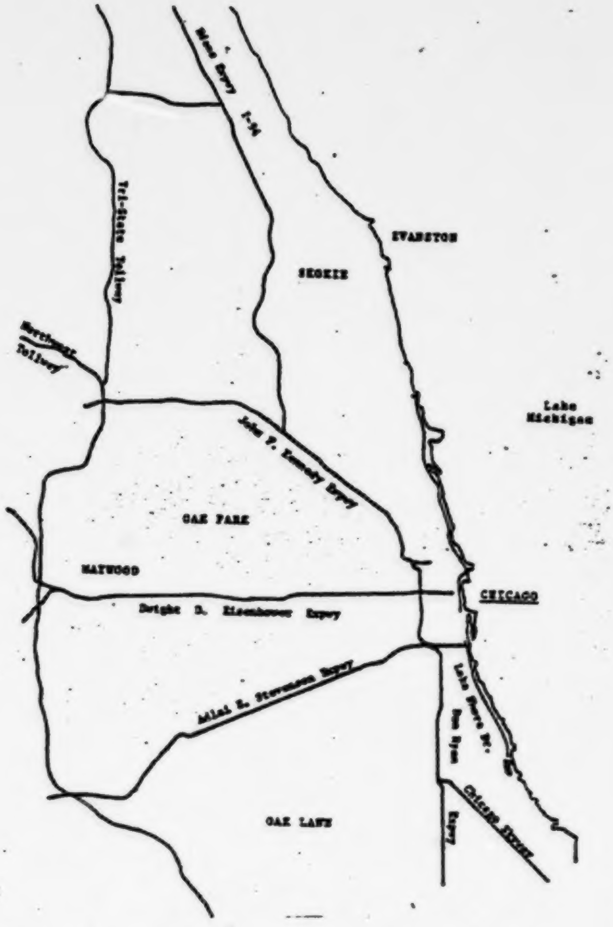

Fig. 2 .2: Chicago Area

Transit Networks

The status of transit operations is crucial to plans for ride-sharing and HOVL programs because of (1) the tendency for expanded ride-sharing to draw from existing bus or rail lines and (2) the sizeable level of bus operations and ridership needed to justify a HOVL, especially on a highly congested freeway. Any changes in the scope or intensity of transit services and patronage requires the breaking of long-established commuting patterns and significant financial risks as expensive bus fleets are expanded or contracted. In addition, the expansion of transit operations generally entails steadily increasing deficit financing that often faces political opposition.

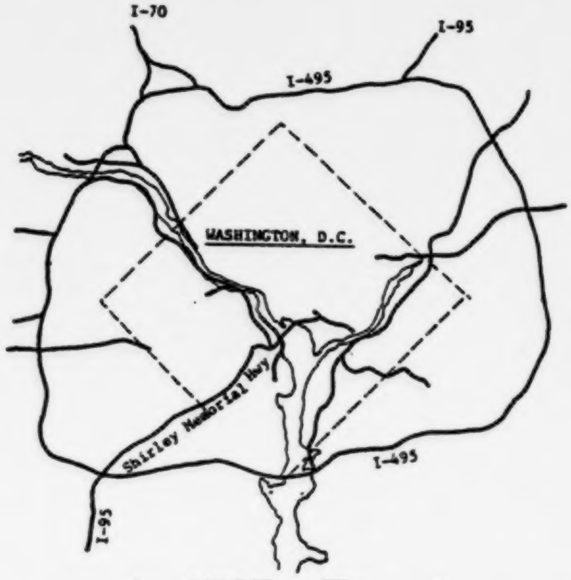

Fig. 2.3: Washington, D.C. Area

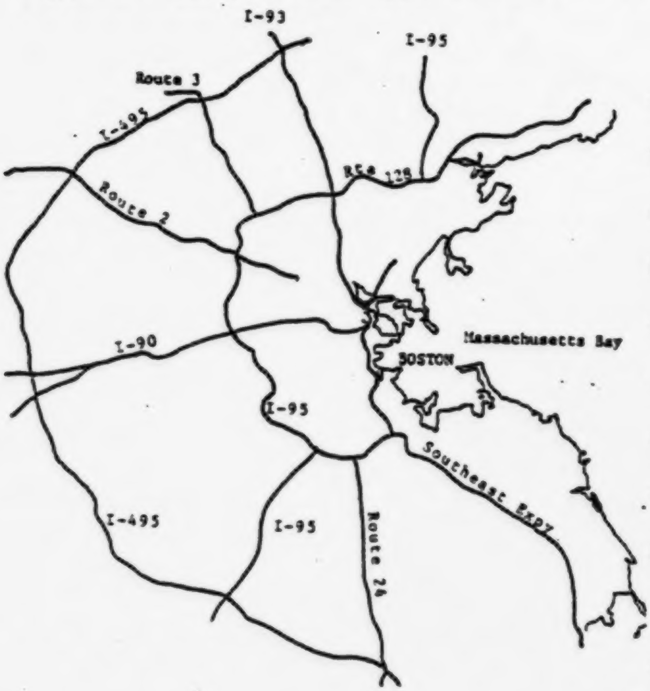

Fig. 2.4: Boston Area

Both Chicago and Boston have maintained the widespread rail networks that were developed in the late 19th and early 20th century. Though the form of these systems have changed somewaht (e.g., Chicago's change from trolleys to heavier gauge rail transit), the crucial role of rail lines in creating and maintaining a densely developed CBD has continued. These rail systems are supplemented by extensive bus systems. Both systems are operating under the pressures of increasing deficits and the desire to minimize fare hikes and service cuts.

Washington, D.C. is in a transitional period as the first stages of the extensive METRO rail system are completed. There is presently no local rail transit other than the ceremonious opening of a small portion of the METRO system and a handful of daily commuter rail trains. The existing METRO bus operations do, however, provide effective transit service to many area residents and numerous suburban express bus lines serve downtown Washington. The Los Angeles area, once served by an elaborate rail network, presently has only a conglomeration of private, municipal, and regional bus operators, the largest being the Southern California Rapid Transit District. Extensive subway transit systems have been proposed but defeated at the polls in the last 10 years. The low residential and commercial density of this region and the lack of dominant CBDs make feasible transit operation difficult and reinforce the political inclination to support systems dependent upon automobiles. The existence of rather extensive bus operations and an excellent system of freeways, however, supports the potential for low-cost HOVL projects, although only a small portion of the region's trips would be affected.

(3) Carpool Programs

Effectiveness in Emissions Reduction

The potential of carpool programs to reduce oxidant levels in urban areas appears low. As discussed in Chapter 1, applying TASSIM and assuming highly favorable local conditions and responses, the projected reductions in hydrocarbon emissions below preprogram levels range from 2.3 percent in Boston to 2.9 percent in Chicago. If more pessimistic assumptions prevail, the reductions would range from 0.06 percent in Boston to 0.1 percent in Los Angeles and Chicago.

As discussed previously in Chapter 1, three factors primarily responsible for this low air-quality impact from carpooling are: (1) Work-trips, the most suitable trip purpose for carpool formation typically account for less than half the total VMT for an area. (2) Large firms offer more opportunities for successful, computerized ride matching and are more easily canvassed by program organizers, but over half of the typical urban area's employees work in firms of less than 100 persons. (3) Employee response to the typical carpool matching program appears to be restrained, as reflected in the maximum anticipated change in average occupancy rates for work-trips being on the order of 15 percent (see Appendices A and C). As an illustrative calculation, if (1) about 40 percent of the area's VMT are for work-trips, (2) 50 percent of the employees work for firms of 100 persons or more, and (3) the "optimistic" occupancy-rate change of 15 percent in response to a vigorous carpool promotion program were assumed, then regional VMT would be reduced by a maximum of 3 percent. The net reduction would be even less because of intervening factors, such as use of the unemployed automobiles by other family members[1] and the additional VMT driven by the carpool automobile in collecting and returning pool members.

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[1] Estimates of this factor have ranged from 23 percent to 40 percent of gross VMT savings. These are very rough figures and further study of this problem is required.

This analytical conclusion appears to be confirmed by interviews and observations in the four city studies (Appendix C). No carpool promotion efforts attained the projected goals of planners, and all evidence indicates that the impact on total travel was miniscule.

Program Outline and Organization

The case studies involved the detailed examination of carpooling on both the firm and regional level. Seven regional carpool matching programs were studied. The overall outline, operations, and effectiveness of each project was examined as well as individual firm experience with carpooling. All but two programs -- Chicago's WBBM and the New Jersey Carpool Program -- were operated and financed through a regional governmental agency. WBBM's effort in 1974 was a totally private operation, while the New Jersey project is coordinated by the regional office of Federal EPA with all matching costs usually paid by the firms. Three programs (MASSPOOL, New Jersey Carpool Program, WBBM) offered free matching services to employers only, while the other four programs combined employer-based efforts with matching services for the general public, although the public matching efforts have universally failed to attract a significant response. The matching programs dependent on large government support (e.g., Washington, D.C., Boston, Seattle, Portland, Los Angeles) used locally matched Federal Highway Administration "FAUS" funds previously allotted to these areas for transportation system improvements.[1]

The general matching process entailed the distribution of carpool matching forms to employees, asking for relevant work-trip scheduling information. Some programs included several personal visits and phone contact between the regional matching office and the firms, but most of the employee contact, in-house publicity and related on-site matters were handled by the firms themselves. In Los Angeles,

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[1] This transfer process is discussed on p. I.14 of Appendix D.

Boston, New Jersey and Washington, D.C., the carpooling efforts were a direct result of environmental control strategies, though only the first three programs specifically required some compliance on the part of employers.

Costs and Benefits

Direct governmental costs for operating a regional ride-sharing program can range from about $1 million, as projected for 1976 in Los Angeles, to about $150,000 being sought by Washington's Commuter Club for 1976 (see Appendix C). MASSPOOL's projected budget is estimated at $600,000 annually. If the costs of the matching procedures are borne by employers, as has occurred in the case of New Jersey's program, the governmental costs are reduced to the partial salary of one professional plus nominal clerical assistance and materials, with total expenses on the order of $50,000 or less. Employer costs are usually low, since the matching process and reporting procedures use existing personnel, computer facilities, and intra-office communication techniques.

The principal benefactors of carpool programs are the employees who take advantage of the often significant travel cost savings that result from switching to carpools. The greatest savings are usually realized by those with longer-than-average trip lengths who switch from single passenger-car travel. Even if a regional matching program reduced daily VMT by only one percent, this can involve millions of dollars in annual travel cost savings, thereby justifying the programs' expense. For example, for Los Angeles with over 166 million daily VMT in 1970, a one percent decrease would reduce annual travel costs by over $60 million assuming only 10 cents/mile for travel costs. Some firms have realized benefits from carpool programs due to the reduced demand for often expensive employee parking facilities and the more intangible improvements in employee morale and public relation. However, it is rare for employers to attribute any significant savings to such programs, but they see the minimal gains as sufficient to cover the administrative costs of their ride-sharing programs.

Future Prospects

Despite the overall cost-effectiveness of carpool promotion programs, three factors tend to limit their future funding from public sources: (1) the meager benefits accruing to the general public, (2) the complex system of geographical and personality variables that restrict the probability of successful pool matches in any group of individuals, and (3) the resentment expressed against governmental involvement in this type of endeavor.

While substantial savings can be realized by individual travelers and, occasionally, employers, no single category of meaningful savings can be attributed to the total public sector. For example, the potential impact upon traffic congestion is minimal. Rides-to-work during peak hours would be the main category affected. Assuming that (a) VMT for that half of the region's employees in firms of 100 or more did decrease three percent, and (b) that work-trips represent 90 percent of peak-period travel, traffic volumes would decrease by less than two percent. In addition, carpooling would tend to concentrate in suburban and rural work locations where traffic congestion is not as severe as on central city streets.

An even more important but not easily analyzed obstacle is the problem of matching potential carpool members by (a) origins and time and (b) social or personality traits. The difficulty with scattered residential origins and irregular working hours has been explored extensively, but problems related to social interaction have not.[1] A recent article in Public Works used a group dynamics session with carpool members in an effort to identify significant personality traits, and the result was the high-lighting of two that appear vital: (a) a sense of punctuality and (b) acceptance of specific behavioral constraints.[2] Lateness, especially in the morning, quickly brings sanctions; and, if it persists, eventual expulsion.

At the same time, the carpool member has to conform to the carpool's social norms. If one member were to smoke all have to smoke. If one wants to listen to rock-and-roll music, all must accept rock-and-roll music. In most cases, certain conversational taboos, such as discussion of work topics, religion, women, or politics exist. Social prejudices also operate. In this study's discussions with some employers, especially in Chicago, employees' families -- particularly first and second generation ethnic families of young women -- reportedly discouraged participation in what was viewed as a potentially intimate riding arrangement with strangers. These factors suggest that a relatively low ceiling — possibly close to the proposed 15 percent "optimistic" improvement in automobile occupancy rates — may exist on the formation of carpools in any specified group of employees.

Public acceptance is a further factor. Many employers, in interviews, expressed acceptance of some role in facilitating carpool formation because they legitimately sensed that the service represented a relatively low-cost employee benefit. On the other hand, many employers also stated that they or their employees resented the direct involvement of a regional carpool agency which they viewed as more governmental intrusion into both private corporate affairs and personal employee information.

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[1] William Berry, "On the Economic Incentives for Commuter Carpooling," unpublished Ph.D. thesis, Harvard University, Graduate School of Business Administration (September 1975).

[2] Douglas P. Blankenship and Michael B. Davis, "Discovering the Rules of Social Interaction for Carpoolers, Public Works (May 1976), pp. 78-80, 106. Another research effort in this area was reported by: Joseph B. Margolin and Marion R. Misch, "Incentives and Disincentives to Ride-Sharing Behavior: Progress Report," presentation at the Transportation Research Board, Washington, D.C. (January 19, 1976).

(4) Vanpools

Effectiveness in Emissions Reduction

Commuter vanpool programs organized by individual firms have been effective in attracting enough riders from within their work forces to support efficient and financially self-sustaining vanpool operations. Unfortunately, only a relatively small number of firms have established such programs,though vanpool efforts have been added to several existing government-sponsored carpool matching programs. Due to the higher occupancy rate of vanpools, these programs require larger firms and longer average trip lengths than carpool programs for effective matching and meaningful travel cost savings. The capital investment in vehicles and the often complicated insurance and licensing processes often dissuade firms from even starting the programs, thus their scale has remained relatively small. Even the most successful vanpool program observed only serves about 8 percent of the firm's employees and reduced the total vehicle trips to the plant by roughly 5 percent (see 3M Company discussion in Appendix D). Thus the potential overall impact of vanpooling on regional vehicular travel and emissions is seen as small.

Program Outline and Organization

The commuter vanpool programs reviewed in detail in this study are all employer-based efforts with no government funding, support, or planning. The fact that these firms were relatively large, ranging from 3,200 to 10,000 employees, suggests that such large concentrations of potential vanpoolers with common trip destinations are necessary for this type of paratransit service to be effective. Though other types of vanpool programs do exist, the employer-based approach is dominant.[1] The employers generally handle the background costs of program initiation, administration, and related rider-matching expenses, while the vans' capital and operating costs are fully covered out of fares.

Two of the employers studied (3M Company and the Tennessee Valley Authority) initiated vanpool programs in response to impending shortages of employee parking spaces, while another (Montgomery Ward) included the program in its overall corporate plan to improve its energy-related public relation. Only Hoffman-LaRoche's vanpool effort was directly associated with any environmental regulation. The TVA vanpooling service was also used to meet the special transportation needs associated with major construction sites where thousands of workers must often travel to remote rural areas with limited transit service, highway capacity and parking. Program administrators often direct their vanpool matching efforts toward those employees who have longer-than-average work trip lengths and try to avoid putting vans in direct competition with existing transit services.

Costs and Benefits

As discussed previously, the pattern of benefits from vanpool programs is similar to those realized from carpooling, since significant travel cost savings can be realized by commuters who switch from private automobile use. In the four programs covered in this report, the average annual travel cost savings for vanpool riders ranged from $640 to $1,500. The greatest benefits were realized by those who switched from long-distance, single-passenger car trips. Reductions in energy consumption and vehicular emissions varied according to the previous travel mode of the van passengers, with the lowest savings realized by the Montgomery Ward program that attracted almost half of its riders from public mass transit. Direct monetary savings for firms were relatively rare with the 3M Company as one of the few notable exceptions with an estimated savings of $3 million due to a vanpool-related reduction in the construction of employee parking facilities. However, van projects have often performed a valuable service in meeting firms' particular transportation problems. In addition to TVA's use of vans at construction sites, companies have used vans (a) to induce employees to stay with their firm by providing low-cost van service, (b) to handle the special problems related to plant relocation from an urban to a rural location, and (c) to handle intra-firm mail or other small deliveries.[1]

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[1] For a discussion of other forms of vanpooling, see G. Miller, M.Green, An Analysis of Commuter Van Experience, The Urban Institute, Washington, D.C. (1976).

Employer costs were difficult to estimate, and several firms were reluctant to discuss cost factors. As in the case of employer-managed carpooling efforts, vanpool project administration and related matching efforts are generally handled by the firm's existing personnel and public relations office, and entail few additional project-related expenses. Rough estimates of project costs provided by firms have ranged from $6 to $60 annually/passenger depending on the number of vans, van ownership or leasing arrangements, and the level of public-relations effort. The costs of initiating programs will probably decrease somewhat since new projects can benefit from the extensive ground-breaking work performed by earlier firms, such as the 3M Company.

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[1] For further information on this topic, see: I. Forstater and E. Twomey, "Vanpooling: A Summary and Description of Existing Vanpool Programs," U.S. EPA, Office of Transportation and Land Use Policy, Washington, D.C. (1976); and G. Miller and M. Green, Guidelines for the Organization of Commuter Van Programs, The Urban Institute, Washington, D.C. (1976).

Future Prospects

Vanpooling programs were not a major factor in any of the four cities studied, although individual firms in each area have been experimenting with this concept and regional carpool programs in Washington, D.C. and Los Angeles are beginning to coordinate and support the commuter vanpooling efforts of area firms. The complicating elements of vehicle purchase, licensing, insurance, and fare collection, and the need for large employee pools with relatively long average work-trip lengths make this approach to ride-sharing a more involved process than carpool matching. Vanpooling has tended to be a private sector phenomenon with the emphasis on totally fare-financed operations, but recent publicly supported vanpool programs in Knoxville Tennessee, and elsewhere may signal a change in this pattern. Difficulties have surfaced in several states over the classification and possible regulation of vanpools as transit vehicles, but their relatively small numbers and favorable environmental and energy conservation image have helped to resolve most of these conflicts. Individual firms as well as communities have shown that vanpool programs can be very flexible and self-sufficient paratransit operations, but their eventual impact on total vehicular travel in urban areas seems limited. Vanpools, like carpools, can play an effective role in the transportation network of individual firms and can provide meaningful savings to their users, but their public benefits and costs are minimal.

Factors Related to Carpool and Vanpool Effectiveness

Based on the findings of both empirical estimates as well as thorough program observation, certain factors can be correlated with the eventual success or failure of carpool and vanpool programs.

1. Optimum Trip Purpose and Location: Journey-to-Work in Urban Fringe, Suburban, and Rural Areas. Carpool and vanpool programs are most successful for the journey-to-work at firms in the urban fringe, suburban, and rural areas. Employment centers in these settings are almost entirely automobile-oriented, have little or no suitable transit service, and may have difficulty attracting a suitable labor force. They must provide ex-

tensive parking which can be expensive, especially when expanding on-site employment makes additional lots or parking structures necessary (Stokey, 1976; Owens and Sever, p.7). Hoffman-LaRoche, Inc., feeling frustrated in its attempts to improve bus service to its plant, instituted both a carpool and vanpool project (see Appendix D). In more urban areas, carpool and vanpool use tends to conflict with transit service (discussed below), but a multi-modal approach using each transit and paratransit option in its optimal travel market can reduce this problem. For example, the TVA experience at its downtown Knoxville, Tennessee location showed how all modes of transit and paratransit could be expanded in their respective markets; from November 1973 to January 1976, bus use increased 860 percent, carpool and vanpool use increased 72 percent while the number of employees driving alone decreased by 68 percent (Stokey, Wegmann, and Chatterjee, p. 4). Furthermore, mass transit cannot survive in markets with relatively low densities at either end of the typical trip and with low off-peak demand. Ride-sharing can provide the substantial savings of a high-occupancy vehicle for the line haul portion of these trips while handling the morning and evening collection in less time than is requried by buses. Vanpools require more "clustering" in residential locations in order to minimize the required collection time of 9-15 passengers compared with 2-5 passenger carpools. Vanpool programs, however, have used the park-and-ride concept in rural areas, collecting passengers along the van's route at pick-up points at which passengers have left their automobiles. Carpool programs often include staging areas for the same reasons (Stokey, 1976; Petrocelli).

2. Typical Relationship with Transit: Competitive. When placed in direct competition with mass transit, carpool and vanpool programs tend to drain transit ridership though notable exceptions exist. The statistical analysis of carpooling at 45 firms in New Jersey (presented in Appendix B of this report) showed that transit ridership and carpooling were negatively correlated, supporting the intuitive feeling of numerous employers that the gradual realization of carpool benefits would draw people

away from transit. Based on EPA's figures for the program's overall results at all 100 locations across New Jersey, employment from May 1974 to June 1975 went down 5.5 percent, but transit use decreased almost 13 percent (EPA, Region II). The impact of vanpooling on transit use was dramatically demonstrated in Montgomery Ward's vanpool program, where roughly half the van riders were former transit users most of whom formerly traveled by commuter railroad (see Appendix D). Chrysler Corporation, however, with its vanpool program weakened by unstable employment patterns and rather high vanpool charges, had to cancel the van project when expanded local bus service offered similar transportation services at a lower fare (McDonald, 1976).

3. Income Distribution of Carpool and Vanpool Riders: No Consistent Pattern. There are no universal income patterns for employer-based programs. The median income figure for van and carpool users compared to other modes varies with (a) the individual firm's location, (b) the travel corridor and residential areas served, (c) the nature of the employment, and (d) the dominant sources of the firm's labor pool. Some studies (Portland, p.54; Metropolitan Dade County (1975), pp.134, 136) found the demand for carpooling to be "income elastic" with carpoolers having an income level higher than both single-passenger automobile users and transit passengers in the same corridor. This can be due to the higher incomes of those living in suburban areas where the cars/household ratio is high and transit service is usually poor, especially to non-CBD locations. Since vanpooling does not require car ownership of its users, they are more likely to come from all income ranges. However, in general, the income characteristics of vanpoolers are very "program-specific," and the quality of income data collected varies from non-existent (Owens and Sever) to a thorough rider survey (Stokey, Wegmann and Chatterjee). The quality of income data by mode of travel was generally poor or not available.

4. Optimum Trip Length: Above Average. Carpools and vanpools attract workers with longer trips. Longer trips mean greater cost savings since variable "mileage"

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costs are greater than for short trips. In Portland, Oregon, survey results showed the average carpooler traveling 50 percent further than the average transit (bus) user and 29 percent further than those driving alone (Portland, p. 48). The data from 100 employment locations in 14 counties in New Jersey showed an average trip length for carpool riders was 68 percent higher than for those driving alone (US/EPA, Region II). One firm surveyed in the Los Angeles area felt that the relatively short average trip length of its employees was the major reason for the failure of carpooling at that location since potential cost savings were low while travel time increases were relatively large. (See Appendix C -- Otis Elevator Company). The vanpool experiences have shown even more dramatic differences. 3M vanpoolers had an average round-trip distance of 50 miles -- over 35 miles further than the 14.4 mile figure for all 3M employees (Owens, 1976). TVA's six-van pilot project had a round-trip mileage range of 40 to 130 miles, compared to an average mileage for car-driving employees of under 50 miles and a transit route range of up to 30 miles (Stokey, Match 1976). In fact, within 3M's vanpool demand forecasting model, a "utility ratio" of pick-up time/line-haul time was used with the assumption, based on employee surveys, that the higher the ratio -- which is inversely related to trip distance -- the greater the probability of a traveler joining the pool (Owens and Seaver, p. 17).

5. Firm Size: Larger Numbers of Employees. The percentage of employees successfully matched by a firm's carpool or vanpool program tends to increase with the number of employees concentrated at that location. A computerized matching program places employees into potential carpool groups based on such shared characteristics as residential and employment location, time schedules, and smoking habits. As more variables are added, the difficulty in finding matches increases (U.S. DOT-UMTA, January 1974, pp. 63-104). For this reason, the more commuters applying to the program, the higher the "matching" percentage will be. Employer-based matching programs at larger job sites, therefore, increases matching potential in two ways: (a) as a firm's employees share a common destination point

and generally similar work hours, the number of variables to be matched is reduced, and (b) the greater number of applicants at large firms increases the probability of a match -- i.e., a firm of 1000 employees might produce 200 carpools, but one with 4000 employees might produce 1000 carpools. One estimate showed these factors to be so important that a region-wide program might need an applicant pool 200 times larger than an employer-based program to obtain an equal number of matches (Berry, p. 137). Statistical observations of 45 employer-based carpool programs showed that a firm's size and the impact of its program on carpooling rate $\frac{(\#\text{ carpoolers})}{(\#\text{ employees})}$ were positively correlated though the relationship was not statistically significant (see Appendix B). Rather than disproving the impact of firm size on matching, this weak correlation shows the importance of other program variables, especially (1) the willingness of employers to thoroughly pursue and follow-up their matching potential, and (2) the role of additional incentives (lotteries, preferential parking) and disincentives (maintain a high employee-parking space ratio).

6. Government Subsidy: None Necessary. Employers prefer to act independently in their carpool or vanpool efforts, based on their perception of their needs and those of their employees. Of the 45 firms surveyed in New Jersey, none took advantage of free matching services available to them from the State's Department of Transportation. Many had voluntarily begun their programs before the State's services were available and such programs were mandated by Federal EPA. The problems of increased fuel prices and supply shortages were often mentioned in interviews with these firms as the key reasons for their programs' initial implementation. Some firms in other areas initiated paratransit programs when more parking facilities for a growing employee population could not be built, as a means of saving the substantial costs of such facilities (Owens and Sever, Miller and Green, pp. 41, 54), or to meet other special transportation needs of their employees. In general, firms did not see the costs of their programs as high and were willing to bear these expenses rather than allow outside interference. Those

firms that were most vigorous in their ride-sharing efforts and therefore most successful in reducing the vehicular travel of their employees tended to be those who perceived meaningful benefits for themselves. Because of the modest expenses associated with a firm providing carpool matching services for its own employees, and the skepticism, fear, or distrust often aired when employees are asked to provide personal information to an outside agency, a case can be made for requesting that (a) firms either do their own matching or (b) that matching programs opt for a low profile approach, limiting their input to behind-the-scene processing and the provision of material.

7. Parking Space Availability: Scarcity Favors High-Occupancy Vehicles. Employment locations with high employee/parking space ratios tend to have more carpool or vanpool formation. Firms with a shortage of parking spaces, especially when employment expansion is envisioned, have a strong incentive to foster greater use of transit and paratransit modes. In the absence of any parking charges (all spaces in the survey were free to employees), the inconvenience of a space constraint is often the only operable disincentive; and it increases the impact of guaranteed or preferential carpool spaces.

Summary Tables

Tables 2.3 2.4 and 2.5 summarize the carpool program variables, including geographic location, administration, costs, and impacts on employee mode split and vehicular travel. Data for these tables were compiled from (1) the published and unpublished reports of investigators in research organizations and various governmental agencies and (2) personal interviews conducted by the authors of this report. For more details and explanations of the data, please refer to the technical appendix following this report.

Tables 2.3 and 2.4 Components and Impacts of Selected Employer-Based Carpool Programs

Data in Table 2.3 were compiled from employers' reports filed with the Region II office of the Federal Environmental Protection Agency. The table outlines the (a) location, (b) numbers of employees and parking spaces, and (c) the employee mode split and VMT at 45 work locations throughout New Jersey both before and after carpool promotion programs were implemented. Table 2.4 describes the types of firms and locations involved, the availability and quality of transit service, and the methods used to support ride sharing at 11 of these employment sites (sites #2 through #12 in Table 2.3). These 11 separate work locations belonging to five firms were selected as a representative sample of the over 100 worksites presently involved in the carpool program. Each was personally contacted to collect the additional information necessary for Table 2.4

The firms in Table 2.3 ranged in size from 502 to 11,000 employees. Transit usage varied from zero to over 62 percent. Efforts to induce employees to form carpools can be characterized as extending from totally ineffective to highly successful. After almost two years of ride-sharing promotion at these firms, (1) the VMT attributable to the 93,200 total employees decreased roughly three percent, (2) average automobile occupancy increased 0.5 percent, and (3) the aggregated mass transit patronage remained constant although five of the eight firms with at least ten percent transit use in the base period experienced a decrease in transit use over the two years.

Data on program costs were difficult to obtain, but most firms regarded their expenses as relatively small. In those instances where a decrease in VMT is coupled with an increase in trips, the disparity is due to differences between the base and final period estimates of VMT per car driven. Since these VMT figures were often arbitrarily selected and based on limited survey information or inconsistent estimation techniques by the firms, the changes in vehicle trips are more reliable measures of program effectiveness. The data in Table 2.3 also show that trip reductions due to increased carpooling and higher automobile occupancy rates may be counterbalanced by lower use of transit, walking, or other non-automobile modes.

TABLE 2. 3

IMPACTS OF EMPLOYER-BASED CARPOOL PROGRAMS ON VMT, #TRIPS, ENERGY CONSUMPTION

CASE-N	Firm Location	Base # of Emps.	Base Emp/ Space Ratio	Base % Transit	1/76 % Transit	% Change in Emp.	Base % Single Car Users	1/76 % Single Car Users	Base % Car-Poolers	1/76 % Car-Poolers	% Change in # of car trips	% Change in VMT per employee	% Change in Auto Occup.
1	Suburban	1100	.95	2	2	-11	73	31	25	69	-34	-34	52
2	Suburban	1609	.85	1	1	5	67	68	32	31	-1	-2	0
3	Suburban	3735	.86	0	0	-34	76	73	24	26	-2	-2	2
4	Rural	1025	.79	0	0	-41	74	81	24	18	5	5	-4
5	Rural	4056	.84	2	2	-2	67	59	30	38	-6	-6	6
6	Suburban	3826	.69	4	2	8	70	56	25	41	-8	-8	12
7	Suburban	2467	.95	3	1	3	59	57	34	41	-0	-6	7
8	Rural	943	1.19	0	0	7	65	68	35	32	2	2	-1
9	Urban	5254	.20	62	57	1	20	19	17	23	4	-4	8
10	Suburban	626	.72	10	5	-19	58	50	32	39	-7	-1	13
11	Rural	903	1.22	4	2	7	72	79	24	18	6	-15	-5
12	Rural	872	.64	9	2	10	67	72	23	24	6	-1	1
13	Suburban	7731	.84	1	1	10	79	79	20	20	2	2	-2
14	Suburban	1689	.83	6	8	40	43	69	51	22	27	10	-23
15	Suburban	1938	.98	0	1	10	64	59	36	40	-3	17	2
16	Suburban	1023	209	5	71	20	70	63	23	29	-7	-5	5
17	Suburban	838	.81	3	2	9	74	66	24	33	-6	-6	7
18	Urban	1129	.53	10	10	-14	69	74	18	13	3	-36	-3
19	Urban	4090	.60	25	20	-19	44	53	30	26	12	22	-6
20	Rural	1009	1.09	1	0	-18	43	44	56	55	3	3	-2
21	Suburban	1344	1.17	3	3	-6	69	57	28	39	-10	-14	11
22	Suburban	657	1.14	4	6	9	84	64	12	30	-12	17	11
23	Suburban	2045	.88	0	0	-14	75	83	17	17	11	14	-9
24	Rural	797	.64	0	0	-3	31	31	63	69	0	-12	-0
25	Suburban	1010	207	1	1	12	81	80	18	18	1	1	-1
26	Suburban	3494	.86	10	4	2	65	72	25	21	14	20	-6
27	Rural	6672	.59	0	0	-7	40	45	60	54	6	6	-5
28	Rural	750	.96	1	1	31	56	69	43	29	12	9	-10
29	Suburban	1013	.73	0	0	-12	70	63	4	18	-3	0	4
30	Urban	1157	.67	1	1	-18	75	76	24	23	1	1	-1
31	Urban	730	1.17	2	8	-8	59	63	14	26	14	27	-17
32	Urban	1856	.43	8	8	-10	75	75	6	6	-0	-1	0
33	Rural	502	1.01	0	0	-7	43	71	57	29	3	28	-22
34	Rural	960	.97	0	0	-13	56	76	44	24	6	6	-6
35	Rural	625	.72	0	0	-7	75	80	22	20	-1	-1	1
36	Suburban	1856	.75	0	0	-16	60	78	39	22	13	-1	-11
37	Suburban	518	1.02	4	2	21	84	65	12	32	-11	-11	15
38	Suburban	1115	.61	1	1	-8	64	72	36	25	4	49	-4
39	Urban	1358	.89	4	7	15	48	69	18	24	42	-6	-32
40	Suburban	775	.81	10	10	-23	71	62	19	32	-6	26	6
41	Urban	1346	.93	1	2	-1	80	86	15	21	10	-4	-9
42	Urban	1401	.86	5	10	3	79	73	16	13	-11	-11	7
43	Suburban	2775	223	10	5	-34	75	63	15	32	-4	-64	17
44	Urban	11000	.26	27	33	-5	64	59	8	17	-17	-17	11
45	Urban	1566	.51	4	4	-9	85	69	11	10	70	-3	1
TOTAL		93195	1.29	10	10	-4	62	61	26	28	-.3	-3	+.5

TABLE 2.4

COMPONENTS AND IMPACTS OF SELECTED EMPLOYER-BASED CARPOOL PROGRAMS

LOCATION	Type of Firm & Location	Mass Transit Service Level	Average Trip Length For Empl'ee (round trip)	Program Elements for Pooling							Annual VMT (wtd.)	Annual Trips (wtd.)	Gas-[1] oline Savings (Annual)
				Matching Method	Publicity Campaign	Parking Controls	Carpool Insurance	Special Awards Drawings, etc.	Other	Cost To Firm			
A	General office & some labs in suburban fringe.	Minimal with recent decreases in service and fare hikes.	36 mi. (1/76)	Employees matched from pay roll data by zip code; updated twice annually locator board.	Ads in house organ, bulletin boards.	Preferred parking for 2+ pools, using pool stickers; all spaces are free.	No.	No.	Worked hard to promote transit.	Sticker program cost 10% of clerk's time;other costs not available.	-209,250 (-1.6%)	-2,250 (-0.6%)	15,500
B_1	Mainly technical research labs in suburban area.	Effectively none.	25 mi. (1/76)	Employee questionnaire computer matching, annual update.	Heavy coverage in house organ.	None for carpools, all spaces are free.	No.	No.	Bus between firm's 4 locations, drop-off service to commuter RR station, encourages use of telecommunications.	None available	-245,500 (-1.9%)	-10,000 (-1.9%)	18,185
B_2	Mainly technical research labs in suburban fringe.	Minimal.	26 mi. (1/76)	Same as B_1.	Same as B_1.	Same as B_1.	No.	No.	Same as B_1.	N.A.	+160,750 (+4.9%)	+6,250 (+4.9%)	-11,907
B_3	Mainly technical research work in rural area.	Minimal.	30 mi.	Same as B_1.	Same as B_1.	Same as B_1.	No.	No.	Same as B_1 with the addition of 1 subscription bus route.	N.A.	-1,444,500	-48,500	107,000
B_4	Headquarters, main administrative offices, centralized services (data processing, payroll,etc.) plus some technical.	Some bus service, but service is being cut back and fares raised recently.	26 mi. (1/76)	Same as B1.	Same as B1.	Same as B1.	No.	No.	Worked extensively to promote transit; minor financial support to local bus, operator to set up new routes.	N.A.	-1,780,750 (-8.3%)	-69,750 (-8.3%)	131.907
C	General office operations w/ some labs in suburban fringe.	Some bus and commuter RR service; problems in arranging expanded service.	27 mi. (1/76)	Questionnaire computes match, updated annually; use house organ to aid in matching process.	Thru house organ, bulletin bds. occasional meetings.	None. All free spaces.	Yes. $1 mill. per accident.	None	Worked hard to boost use of transit, privide schedules to employees, advocate use in house organ,etc., but generally frustrated by poor service.	Each update of matching data costs roughly $100. No other cost data available.	-712,000 (5.5%)	1,500 (-0.3%)	52,720

[1] Assumes 13.5 mpg

TABLE 2.4 (Cont.)

LOCATION	Type of Firm & Location	Mass Transit Service Level	Average Trip Length For Empl'es (round trip)	Program Elements for Pooling							Annual VMT (wtd.)	Annual Trips (wtd.)	Gas-oline Savings (Annual) 1/
				Matching Method	Pub-licity Cam-paign	Parking Controls	Car-pool In-sur-ance	Spe-cial Awards Draw-ings, etc.	Other	Cost To Firm			
D	Administrative office, with high % of top personnel in rural setting.	None.	25 mi. (1/76)	Voluntary compter matching w/mapping board to aid process; no data on frequency of updating.	Standard in-house campaign; made car-pool movie w/H'wy Users Federation.	None All free spaces.	No.	No.	Did feasibility study of charter buses to meet transit needs; did work with local towns to boost transit; improved limousine service to airports.	N.A.	+101,250 (+2%)	400 (+2%)	-7,500
E_1	Central administrative offices in downtown CBD location.	Good bus, subway and commuter rail service.	16 mi. (1/76)	Survey-based invitation to carpool meetings where prospective poolers were seated by residential area, to induce carpool formation; done annually with carpooler list available to employees.	In-house organ, pamphlets.	Parking by permit, w/new permits to pools only, no charge for spaces; carpools get preferential spaces.	Yes. No $ coverage data given.	None.	Support of transit service; working with local transit operators and gov't agencies.	Each survey costs ~$25,000, other costs not available.	-296,500 (-4.4%)	34,500 (+9%)	21,963
E_2	Sub-regional office, with fairly high concentration of lower skilled office workers in suburban setting.	Low.	20 mi. (1/76)	Same as E_1.	Same as E_1.	None. Spaces are free.		None.	Vanpool service starting.	See E_1.	-23,500 (-1.3%)	1,500 (+1.7%)	1,741
E_3	Sub-regional office, firm's computer center, high percentage of upper-level employees in suburban area.	Low	22 mi. (1/76)	Same as E_1.	Same as E_1.	None. Spaces are free.	Yes.	None	None	See E_1.	-830,500 (15%)	-27,500 (14%)	61,519
E_4	General office mix, mainly clerical in suburban setting.	Low.	17 mi. (1/76)	Same as E_1.	Same as E_1.	None. Spaces free at firm and other free spaces at adjacent lots.	Yes.	None.	Vanpool service starting.	See E_1.	-27,500 (-.7%)	30,250 (+17%)	2,037

1/ Assumes 13.5 mpg

Information in Table 2.1 plus related data were subsequently used for the statistical analysis of employer-based carpool programs contained in Appendix A of this report.

Table 2. 5 Components and Impacts of Selected Regional Carpool Programs

Data in Table 2.5 were compiled from project reports and extensive personal contact with their administrators. More detailed discussions of these programs are presented in the appendices of this report.[1]

All programs presented in Table 2. 5 are regional matching programs that concentrate on increasing carpooling at large employers in urban, suburban, and rural areas. Only the Commuter Club program provides matching services to the general public, while only the New Jersey project does not perform the actual matching, which is done by the individual firms. The other three programs provide free matching services to firms with almost all expenses covered by the transfer of FHWA funds from other transportation projects. These programs vary widely in project costs, due mainly to differences in (a) the size of target areas, (b) the extent of reporting and data analysis, and (c) the amount of personal contact with employers. Data on program impact were scarce, but the projects observed shared a common pattern of rather minimal effectiveness in reducing vehicular travel. All programs are slated to continue, with no major changes in the projects' basic approach other than the addition of small vanpool programs in Los Angeles and Washington, D.C.

Table 2.4. Components and Impacts of Selected Employer-Based Vanpool Programs

The data in Table 2.6 were derived from employer-based vanpool programs in four different sections of the country, and they outline each firm's size, location, type of operation, and vanpool program characteristic costs, and impacts. The first three are private firms, while TVA is a quasi-public authority.

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[1] A summary table of the Portland and Seattle carpool programs which are reviewed in Appendix D is presented at the end of that appendix.

Vanpools in these programs carry from 3.8 percent (Montgomery Ward) to 8.3 percent (3M) of the employees, and each van removes from 3.4 (Montgomer Ward) to 10.4 (Hoffman-La Roche) cars from daily commutation. The low trip-reduction figure for Montgomery Ward is due to its downtown Chicago location. Roughly half of its vanpool passengers originally used various transit modes, while almost all riders in the other programs came from private automobiles. The average van trip length and fares for these programs all fall into a fairly tight range. The average savings in personal commutation costs range from $850 to $1500, the principal determinant being the previous mode used, including the average automobile occupancy of those who formerly drove to work by car. The fact that the workforce at these four locations is relatively large (3,200 to 10,000 employees) is an important factor, since such large employee concentrations are necessary to successfully match 10 to 12 persons from approximately the same residential area or commutation route.

Table 2.5

COMPONENTS AND EFFECTS OF REGIONAL EMPLOYER BASED CARPOOL PROGRAMS

Program and Setting	Program Description	Implementing Agencies	Program Impetus and Requirements	Program Funding	Base Conditions	Program Effects	New Program Features
New Jersey Employer Incentive Program Began early 1974. Affects NJ firms in NYC and Philadelphia AQCRS	Firms must provide employee incentives for carpooling and/or transit. Existing indiv. programs include matching services (computer and employee initiated grid display methods), preferential parking, vanpool programs, and promotional events.	Indiv. firms devise programs. EPA II oversees program. NJ DOT provides optional computer matching to public and private firms.	N.J. TCP reg. 52.1590 requires incentive programs of employers with 400+ parking spaces. EPA II collected base data, and requires 6-month update reports from firms on pro-program effects.	Employers bear program costs. EPA II supervision handled part-time by regular employee.	Reached 100 facilities with base employment 185,000. Based on 45 facil: -Auto occupancy rate 1.26 -Pre mode split 62% single 26% carpool 10% transit	1/76 results based on 45 facilities: -Auto occupancy rate of 1.27 -Post Mode Split 61% single 29% carpool 10% transit -VMT per employee dropped 3%.	Continue present programs and monitoring.
MASSPOOL Began late 1975. Affects firms in all major population centers of Mass., but mandatory only upon Boston Metropolitan Region firms.	Central State agency provides intra-firm computer matching, and/or provides promotional material and grid maps to firms. Planned HOV lane for S. E. Expressway; includes carpool staging lots.	Administered by Mass. Executive Office of Transportation and Construction. Implemented by 2 consulting firms. Part time assistance from Mass. DPW.	Mass. TCP reg. 52.1138 and 52.1161 require State to do computer matching and otherwise promote carpooling, specifically among firms with 250+ daytime commuters. Executive Office is collecting base data, and requires 6 month reports from firms.	1975-77 funded at $600,000 annual. Funded 90:10 betw. FHWA and State under EHEC Act of 1974. Administrator funded under unrelated UMTA grant.	Expect to reach 600-700 firms. Have base data on 140 firms; 119,000 employees: -Pre Mode Split 41% single 16% carpool 34% transit	No results as yet. Expect 1-3% drop in work trips, and work trip VMT.	Planned and will aid implementation of SE Expressway HOV lane in near future.
Commuter Club Begun late 1973. Affects firms and general public in Wash., D.C. metropolitan region.	Central planning agency provides some intra-firm and many more inter-firm computer matches; and/or provides promotional material. Since 1976, matches public via phone requests and submitted applications.	Administered by Washington Council of Governments, with assistance from Met. Wash. Board of Trade and Federal Govt. General Services Administration.	Wash, D.C. TCP required agency to do computer matching and carpool promotion. No employer participation required. GSA proposed 90% of Federal parking areas for each agency (but not for each site) be for carpools exclusively.	1974-$60,000; 60% from COG funds, 40% from EPA III. Charged 25¢ per quest. to firms. In kind aid from D.C., CSA, Board of Trade, NVTC. 1975-$212,000 from Fed. Highway Plan. and Org. funds from D.C., Va., Md. 1976-$150,000; same sources.	Contacted 800 firms, distributed 372,000 questionnaires. Received back 21%. No employee pre-mode split.	Of 78,000 questionnaires returned, 82% matched and 5500 presumably formed carpools. In summary, 1-2% of total population approached formed carpools.	Expand public matching. Possible vanpool info. and promotion service for firms, if COG receives EPA III funds.
Commuter Computer Begun early 1974. Affects firms and general public in 5 Los Angeles area counties.	2 offices provide intra-firm computer matching for potential regular carpoolers and smog alert carpoolers. Provides some matching from public requests. Began inter-firm van-pooling in	Recommended and overseen by Southern Calif. Assoc. of Govts. Implemented by Computer Transportation Services, Inc., a non-profit firm.	Recommended in SCAG 1974 Short Range Trans. Plan. Employer based smog emergency carpool matching required by Air Pollution Control Board. Other firm participation not required.	1975-$541,000, plus in kind aid from industry. 1976-$950,000, almost all funded 90:10 from Federal Aid Urban Systems; 10% share from SCAG, LA City, 5 counties, other sources.	Contacted 700 firms, formed a matching data base of 60,000 employees (60% regular matches, 40% emergency). No employee pre-mode split.	'75 estimate that 5000-7000 of matches formed carpools. Sample 18 firms, 18,000 employees Post-mode split: 64% single 20% carpool 4% transit.	'76 plans to add 12,500 carpoolers to total by doubling data base. In April, 1976 began (with ARCO) an inter-firm vanpool pilot program.

TABLE 2.6

COMPONENTS AND IMPACTS OF SELECTED EMPLOYER-BASED VANPOOL PROGRAMS

	Firm Type & Location	# Employees	# Parking Spaces Transit Service & % Using Transit	Vanpool Startup Date & # Vans	Present # Vans & Passengers	Average Van Route Mileage and Monthly Fares	ΔVMT (annual)	ΔVehicles Trips (annual)	Gasoline Consumption (annual)	Estimated Employee Savings	Estimated Employer Costs and Savings	Former Mode of Vanpool Riders
Hoffman-LaRoche	Offices & some production in Nutley, N.J., a suburban area	∼6,200	4610 free spaces 3% of employees using fair to poor transit service	2/74 4 vans	20 vans 240 pass. @ 12 pass. per van	55 miles @ $26.47	-2.6 million (130,000 per van)	-52,250 (2600 per van)	-200,000 gallons	$350,000 ($1500/ rider)	∼6,500/year for vanpool/carpool/ transit program. No savings figure given	HL officials assume: 100% single auto Authors: ≃88% single auto 12% other auto
3M Company	Main headquarters - largely offices but some labs - located in suburban St. Paul	7700 in 1970 ∼10,000 in 1976	∼7200 free lot spaces & 800 garage spaces @ $15/month (vanpools park free in preferred garage spaces)	4/73 6-12 pass. vans	75 vans ∼830 pass. @ 11.1 pass. per van	50 miles @ $27.40	-5.2 million (70,000 per van)	-103,250 (∼1400 per van)	-380,000 gallons	$700,000 ($850/ rider)	Substantial program expenditures (2 full time personnel + part-time engineer), but estimate $3mil. in forgone parking space construction and good publicity.	49% single auto 7% drive w/pass. 23% carpool rotaters 16% carpool riders 4% dropped off 1% transit
Montgomery Ward	Corporate Headquarters - full range of office personnel located in northern Chicago	∼4000	No figure available, but stated by MW to be "ample free parking" and good transit service(no % given)	10/74 6-12 pass. vans	14 vans ∼151 pass. @ 11.2 pass. per van	56 miles @ $30.60	-476,000 (34,000 per van)	-8,500 (607 per van)	-33,800 gallons	$150,000 ($640 for former transit riders, $925 for former auto travelers)	Estimate administrative cost of 15 man hours/ month - no other figures available No savings mentioned.	31% {single auto rotating pool drove w/pass.} 19% {rider dropped off} 50% transit
Tennessee Valley Authority	Authority's Headquarters in downtown Knoxville; full range of office and managerial workers	3200	No figure available	6/74 6-12 pass. vans	12 vans (6-12pass. 6-15 pass.) 140 riders @∼11.6 pass. per van (13 vans at other TVA sites)	No figure given but estimate of 70 miles @ $28.66 used	-1 million (∼83,000 per van)	-17,500 (1460 per van)	-73,000 gallons	$136,000 ($1000 per rider)	Most costs covered by fares, but were TVA administrative costs (surveys, publicity, etc.) but no cost or possible savings data available.	42% single auto 58% carpoolers (total drivers and riders)

167.

(5) Preferential Lane Programs: HOVLs

Effectiveness of Programs

The projected potential for HOVLs to reduce hydrocarbon emissions is low. Applying the estimated observed HOVL-related transit travel time savings to the TASSIM model, the impact on hydrocarbon emissions for the test cities ranged from a low of 0.3 percent for Chicago to a high of 0.8 percent for Washington, D.C. As in the case of ride-sharing programs, a relatively small proportion of a region's total trips is involved. HOVLs usually succeed only in CBD-directed corridors during the peak hours when work trips dominate. However, in a typical case such as Boston, only four percent of the automobile work trips enter the CBD. Even if a quarter or more of these automobile users could be persuaded to use buses by a HOVL-related reduction in transit time, the impact on total traffic volume would be small. In addition, the improvement in overall hydrocarbon levels would be limited by emissions from (a) the induced use of cars now left at home and (b) transit riders driving to park-and-ride facilities before boarding the HOVL buses.[1] These induced demand factors are significant because pollutant emissions rates are highest during the "cold start" and "hot soak" periods of a trip. Therefore, if a person drives five miles round-trip to a park-and-ride lot as compared to a 25-mile commutation trip, the reduction in hydrocarbon emissions is only a small fraction of the 20 percent decrease in VMT. For this reason, an environmentally effective program must reduce both VMT and vehicular trips.

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[1] One estimate gave 23 percent of HOVL-related VMT reductions lost to these types of "leakage effects." See Bigelow-Crain Assoc., Second Year Report - San Bernardino Freeway Express Busway Evaluation, (Sept. 1975).

Successful HOVLs can significantly increase the long-term person-carrying capacity of individual roadways, thus reducing the total cost of these trips and the eventual need for additional highway investments. Also, even though traffic volumes on the respective highways have rarely decreased after a HOVL was implemented, the normal rates of increase in vehicular travel have been diminished. Part of the difficulty in persuading automobile users to shift to HOVL buses is that total transit travel time is still greater than by automobile. While time savings do usually occur on the preferential lane portion of the trip for both highway and arterial HOVLs, these are generally offset by the collection and distribution time required by the buses. Furthermore, HOVLs require the expansion of bus fleets, routes, and park-and-ride facilities in order to make an impact on the existing modal split patterns; and the newly attracted riders generally place service, convenience, cost-savings, and other factors above HOVL travel-time reductions when making their modal decisions.

In summary, HOVLs can be effective in improving the travel conditions for preferred vehicles on their respective roadways; but, since the impact on overall modal split is small and the number of suitable corridors for HOVLs is rather limited, the eventual environmental impact is necessarily small.

Program Outline and Organization

Of the nine HOVLs examined in detail in this report, two were on CBD-oriented arterials and seven were on sections of major urban freeways. Most of the programs were originally conceived and justified on the basis of improved highway system efficiency rather than environmental concern, although pollution and energy considerations are presently the principle forces behind most new HOVL projects. HOVL programs on expressways are normally operated by the state departments of

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[1] The proposed CBD Buslane and Stevenson Expressway Projects in Chicago as well as several future HOVL plans for the Los Angeles area were also discussed. (See Appendix C sections on these cities.)

transportation while inner-city lanes generally fall under municipal or county control. Bus services are usually provided by both the regional transit authorities and private bus operators whose routes and scheduling are under local or regional control.

The size and types of HOVL operations vary widely. Lengths range from 1.4 miles to over 11 miles and types extend from low cost lanes with minimal project-related capital improvements to multi-million dollar, physically separated roadways. Operations are almost exclusively limited to morning and evening rush hours while those connected with short-distance traffic bottlenecks, e.g., the entrances to the Midtown and Holland Tunnels into Manhattan and I-93 Bridge in Charlestown, Massachusetts, are usually limited to morning peak-hour operation. In addition, the HOVL concept in recent years has moved away from bus-only lanes to carpool/bus lanes, as shown by the use by carpools of the Shirley Highway busway since 1973 and the similar project adjustment scheduled for the San Bernardino busway in early 1977. Often such joint use of reserved lanes or roadways are required to reach the volume of person-trips necessary to justify its exclusive use and meet the often intense public reaction of commuters who observe what they feel is underutilized freeway space while they travel in heavily congested traffic. Some facilities have separated lanes for buses and carpools (South Dixie Highway) while other HOVLs (Long Island Expressway, I-495 approach to Lincoln Tunnel) have a strictly bus-only policy that is easily justified by the high bus traffic volumes on those roadways during the lanes' rush hour operations.

Program Costs and Benefits

Cost estimates for HOVLs are generally low in highway construction terms, but they are often inflated by the inclusion of unnecessary, though desirable, roadway improvements. The marginal costs necessary to the lanes are normally for planning, monitoring, enforcement, and special signs. Operating costs for contra-flow lanes tend to be higher, especially for "peak-period only" lanes that require the setup and removal of lane dividers. In the case of the Southeast Expressway in Boston (8.4 miles), initial implementation costs are budgeted at about $14,000, with annual operating costs expected to average $75,000. The latter figure can drop to insignificance if daily setup and removal of dividers proves unnecessary. This estimate does not include enforcement, the leasing or purchase of park-and-ride facilities, or any additional planning, monitoring, and evaluation expenses. Implementation costs for the 12.6-mile with-flow "Diamond Lane" on the Santa Monica Freeway have been estimated at $70,000 with operating costs assumed to be nominal. The construction costs associated with major preferential facilities, such as the San Bernardino and Shirley Highway HOVLs, are obviously much higher -- averaging $4 million to $6 million per mile. Future costs for similar projects would be higher, of course.[1]

The principle benefactors of HOVL programs are the travelers themselves. The major HOVLs reviewed in this study reduced the total travel time for buses by 16 to 20 percent which provides time-savings to present riders and an inducement for those contemplating express bus use. One HOVL project's analysts attributed over $2.6 million in annual HOVL-related travel time savings to carpool and express bus riders.[2] The main benefits realized by former automobile users, however, are the reduced travel costs. In general, those who formerly rode transit saw their travel time decrease and travel cost increase if they switched from regular to express service, while former automobile commuters traded increased travel time for lower travel costs. Public and private transit operators benefit from increased ridership and smoother operating conditions, although the impact on the financial straits of regional transportation networks is minimal. In addition, rider surveys have shown that express bus service in markets with existing transit routes tend to attract most of their riders from existing transit. (See discussion of the Long Island Expressway HOVL in Appendix D.)

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[1] For example over the 1973-75 period, the composite cost index for Federal-Aid Highway cosntruction in urban areas increased by almost 40 percent. See U.S. Dept. of Transportation, FHWA, "Price Trends in Federal-Aid Highway Construction," Office of Highway Operations.

[2] See discussion of the South Dixie Highway HOVL in Appendix D.

Future Prospects

Except where the HOVL by-passes a local congestion point or adds a lane to existing expressways, thereby providing HOVL preference without constraining traffic in other lanes, the political acceptability of a HOVL cannot be assumed. The strong negative public response to the with-flow Santa Monica HOVL in Los Angeles and political sensitivity of a proposed similar operation on the Southeast Expressway in Boston are clear examples of the public's attitude concerning automobile constraints. (See discussions in Appendix C.) Additional factors acting against the widespread application of HOVL strategies are (1) the large expansion in the transit vehicle fleet required to handle the increased ridership, (2) the longer travel time required for most commuters shifting from private automobile to express buses or carpools, (3) the often limited number of corridors and highways suitable for relatively low-cost HOVL implementation that could eventually handle the volume of bus and carpool traffic necessary to justify a reserved lane, and (4) in many cases, higher actual or perceived personal costs in terms of both money and convenience due to switching to express bus service. These programs must combat the social inertia of the last few decades when attempting to shift travelers from private automobiles to transit or paratransit modes. In addition, the reduction of traffic congestion can often induce more vehicles onto the HOVL -- the traditional traffic management paradox that can cancel some of the lane's gains.

Although in terms of reduced air pollution, energy consumption, and traffic congestion their social benefits are small, most low-cost HOVL programs can be easily justified on a cost/benefit basis. Evaluation of the cost-effectiveness of major busway projects like those on the Shirley and San Bernardino Highways, however, requires a more detailed study. Of major importance in the eventual benefit/cost calculation will be the selection of vehicle types which will have access to the facility, including the trade-offs involved in (a) bus-only HOVLs _versus_ buses and carpools, and (b) various minimum carpool occupancy rates for HOVL access.

Factors Related to HOVL Effectiveness

Based on the observation of numerous preferential lanes in various regions of the country, certain factors can be correlated with the eventual success or failure of the HOVL project.

1. _Optimum Trip Purpose: Journey-to Work_. Since bus lane programs are generally operated within corridors between the CBD and residential areas during one or both peak-periods, it should not be surprising to find that 90 percent or more of the person-trips are commuter work-trips (see Table 3.1). Limited data from the South Dixie Highway HOVL indicate that work-trips in the peak-periods make up over 95 percent of HOVL person-trips but only 83 percent of the trips in the non-priority lanes (Metropolitan Dade County, 1975, p. 6). Survey information shows that carpool and transit options are less attractive for non-work trips;

priority lanes are generally implemented in CBD-oriented corridors (exceptions are noted in Bigelow-Crain; Mark, et al.), and transit service is more infrequent in the off-peak periods when most work-trips are made, both of which make preferential lanes of most value to those commuting daily to work in the CBD.

2. Scale of Effectiveness (VMT, Trips): Stabilization of Vehicular Travel Growth. Buslanes on highways and certain arterials tend to stabilize or slow the growth of vehicular traffic volumes despite increased person-trips. A slight reduction in vehicle trips has temporarily occurred in a relatively few cases; but, in general, traffic volumes rise even with bus lane implementation. However, the yearly growth of additional person-trip movements has been partially accommodated by expanded bus and/or carpool use (MacCalden, 1973, p.3). Even where temporary reductions in traffic volume have been achieved, the fact that most HOVL projects expand the highway capacity available to all vehicles has often induced higher, mixed-traffic volumes in the non-preferential lanes (see Bigelow-Crain, p.xvii; UMTA, Shirley Highway, 1975).

3. Effective Arterial HOVLs Require Other System Improvements. Bus lanes on city streets and certain arterials are only effective when coordinated with other "throughput" improvements, including signal synchronization and turning restrictions. When the implementers of one project deliberately tried to preserve all pre-project factors except for the legal designation and signing of a bus lane, the supposed benefits of preferential lanes did not materialize. In fact, a worsening of priority vehicle congestion and travel delays occurred (Baltimore). Although no changes in modal split or vehicular use were noted, project officials believe that a more careful survey might have shown that automobile use had increased at the expense of preferentially treated bus ridership (Erdmen). By

comparison, when an on-arterial HOVL in Miami was coordinated with a total traffic management program including increased police enforcement, expected results occurred, especially increased priority vehicle use as well as a leveling off of normally increasing traffic volumes (see Metropolitan Dade County, 1975).

4. Optimum Market: Higher income professional and technical workers. Bus lane users tend to have higher income levels than non-users in the same corridors. In specific instances, average bus rider and/or carpooler income was between 20 and 30 percent greater than that of the surrounding metropolitan area (Shirley Highway; Polytechnic, pp. 38-39). The percentage of professional and technical workers among express bus riders was higher than the average for the areas serviced by these routes (Mark, et al.). However, in cases when preferentially treated transit was considered inferior to either priority carpools, or even non-priority automobiles -- in terms of out-of-pocket cost, total travel time, and comfort -- the median income of those attracted to express buses was below that of both carpoolers as well as those driving alone (Metropolitan Dade County, 1975, p. 77; Erdman). The income distribution of HOVL users tend to be high due to (a) the basic characteristics of the suburban areas served by the highway (e.g., the higher income suburbs of northern Virginia or Queens, New York served by the Shirley Highway and Long Island Expressway respectively), and (b) the relatively high fares on express bus routes.

5. Role of Park-and-Ride Facilities: Significant Patronage Generator. Park-and-ride facilities provide a significant source of bus lane patronage, although the effect may vary in strength according to the area's land use. In serviced areas of largely suburban character, especially those that are growing, between 25 and 55 percent of bus lane riders boarded express buses from park-and-ride lots (Metropolitan Dade County, 1975, p.61; Shirley Highway; Bigelow-Crain, p.xiv).

The significance of the share is due only in part to the designation of park-and-ride lots as an element of bus lane programs. In two instances, some 50 to 80 percent of park-and-ride patrons use unofficial parking lots or on-street spaces for their change of mode (Metropolitan Dade County, 1975, p. 61; Shirley Highway). In areas of higher population density, usually older city fringes and inner-suburbs, park-and-ride performs a far less significant role, as in one instance where over 90 percent of bus lane ridership walked to their express bus-stop (Polytechnic, p. 40). Transit riders have expressed a strong preference for this type of door-to-door express service (Shirley Highway, 1975; Polytechnic, p. 40).

6. The Importance of HOVL-Related Travel Time Reduction: Marginal.

The transit travel time improvements that bus lanes offer cannot by themselves have a significant impact on ridership levels, especially when extensive express bus service previously exists in the corridor (see Polytechnic, p. 45; Murphy; Graham; Tri-State, 1972). Studies have shown that travel time savings are only a minor factor affecting patronage of express bus service. Even when travel time on the exclusive lane portion of a freeway is less for buses than for non-priority automobiles, this still represents only the line-haul segment of a total trip that generally can be made faster by private automobile (Bigelow-Crain, p. 53; Shirley Highway). Programs combining an HOVL with new express service also indicate the relative unimportance of the lane's travel time savings, as shown by one instance where total peak-period express bus ridership grew by 900 percent although less than 25 percent of the former automobile users indicated time savings as their main mode-switch decision variable (Bigelow-Crain, p. 55). Ridership levels are, in fact, more sensitive to other program variables, such as extensiveness and frequency of bus service (Metropolitan Dade County, 1975; Polytechnic; Shirley Highway; Bigelow-Crain, p. 73), cost savings (Bigelow-Crain, p. 66), and comfort and convenience (Polytechnic, p. 45; Bigelow-Crain, p.66; Shirley Highway). Carpool usage on designated HOV lanes is also more sensitive to many of these same variables, especially cost savings (Shirley Highway; Caltrans, 1975), since carpoolers usually increase their overall travel time in collecting passengers (Metropolitan Dade County, 1975, p. 81; Gallagher, p. 4; Shirley Highway).

Summary Table

Table 2.7 Components and Impacts of Selected HOVLs

The data in this table outline the HOVLs' operating characteristics, capital and operating costs, and impacts on vehicular travel. The nine lanes -- two on CBD-oriented arterials and seven on sections of major urban freeways -- range from 1.4 miles to over 11 miles in length and from $35,000 to $57 million in implementation costs. Both of the street/arterial HOVLs and four of the seven freeway lanes are for buses only, while the Shirley Highway, Santa Monica, and I-93 HOVLs allow buses and carpools . The new Southeast Expressway with-flow lane, tentatively scheduled to open in early 1977, will carry both carpools and buses. All but one (San Bernardino) operate during morning and evening peak traffic periods only, and the three short lanes located at tunnel entrances (Long Island Expressway, I-495) and on bridges (I-93) operate only in the morning peak period. Substantial increases in bus traffic and patronage were measured on all projects. In the three cases (York Road, Santa Monica Freeway, South Dixie Highway)where implementing the HOVL entailed a reduction in number of lanes available to mixed traffic, travel times for non-preferred vehicles were increased. Data on the commuters' previous mode of travel showed that roughly two-thirds of new bus riders on these HOVL projects had formerly traveled by car, except for the Long Island Expressway lane where almost all express bus riders formerly rode New York City's subway and local bus systems.

In only two cases did an absolute decrease in vehicular use occur: the Santa Monica Freeway and the South Dixie Highway. Since data for the Santa Monica Freeway were collected only weeks after its opening in the spring of 1976, the eventual status is unclear. In all other cases, when information was available the vehicular use either remained constant or rose.

TABLE 2.7 COMPONENTS AND IMPACTS OF SELECTED HIGH-OCCUPANCY-VEHICLE LANE PROGRAMS

				PROJECT EFFECTS					
Project and Geographical Setting	Project Description	PARTICIPANTS: Planning Implementing Financing	Implementing & Operating Costs	Travel Time Changes	Trip Purposes and Rider Characteristics	Passenger Modal Shifts	Change in Vehicle Occupancy and/or Change in Ridership	Change in Vehicular Use	Change in Annual VMT
CITY STREET/ ARTERIAL July 1974 So. Dixie H'wy -links Miami, Fla. with suburban south Dade, 5.5 mi. south; pop. 210,000 -4 to 6 lanes, signaled intersections -70,000 daily vehicles -16,000 PM peak	1) Bus contra-flow and 2-passenger carpool with flow lanes. Operational with peak direction flows. 2) Left turn restrictions. 3) Traffic flow improvements. 4) Expand express bus coverage by 600%. 5) Designate 5 fringe parking lots, and 1 CBD carpool lot. 6) Increased police surveillance.	State DOT Local -Metropolitan Dade County -4 police forces -Chamber of Commerce	Implementation $.69 million Operating $.87 million ~50/50 split between State and Metro. Dade County	Bus Lane -10 to -19 min. 50% to 60% Savings in line haul time. Carpool Lane -2 to -6 min. 13% to 30% Savings in line haul time. General Lanes +1.3 to +3.25 min. 7% to 20% Loss in line haul time. Total trip Bus total trip time reduced 17%	Bus Lane 95% worktrip Med. income $15,000 Carpool Lane 88% worktrip Med. income $21,000 General Lane 83% worktrip Mean income $16,000	Bus Riders 66% single occupancy 11% carpoolers 23% transit Carpoolers 61% single occupancy 27% carpoolers 5.5% transit	V'cle Occup. Increase ~15% from 1.25-1.38 to 1.45-1.6 Carpool vehicle occupancy 2.16 Bus Riders 350 daily, pre-project >2,000 daily, 1 year later Carpool Riders Approximately 5,000 new carpoolers	The number of auto vehicles fell by between 2% and 10%, depending on base periods chosen. At same time number of passengers increased by between 4% and 12%.	Reduction of 21.6 millio for total tr Reduction of 8.5 million along 5.5 mi corridor: 16% reductio
July 1974 York Rd./Greenmount Av. -Links Baltimore CBD to Towson suburban area, 3/4 miles north. -Narrow road corridor, with no major peak congestion problems -12 to 20 local and express buses per peak hour.	1) Experimental exclusive bus lane along curb during peak hours. Allow Express and local buses, right turning autos, and autos avoiding left lane delays, or turns. 2) Limited police surveillance 3) All other factors kept same; project objective to measure travel time change for bus and autos, due only to exclusive lane designation.	State Maryland Mass Transit Administration Local -Dept. Transit & Traffic -Dept. Planning -Mayor Federal Region III EPA ordered experiment.	Costs of lane designation & project evaluation indeterminable by project officials. All costs incurred for lane designation, however, would have been City financed.	Bus Travel Time on Lane Average Increase of 2.4% Auto Travel Time on Non-profit Lanes Average increase of 6.1%	Trip Purpose Peak period work trips.	Did not seek this information.	No change in bus ridership noticed from limited bus counts.	No change noticed.	No Change.
FREEWAY RELATED Feb. 1974 I-93 -Links Boston to northern suburbs -2 tier structure with southbound 4 lanes underneath in Charlestown -2-hour AM peak of 5,115 total vehicles; 560 carpools; 31 buses.	1) Left lane bus and 3-passenger carpools exclusively for 1.4 miles on southbound tier in Charlestown. 2) Operates 6:30AM-9:30AM 3) Third lane became barrier separation 4) Preferentially treated traffic given head of line advantage at lane's end. 5) Enforced by expelling violators from I-93, increasing travel time up to 20 min.	State -Dept. of Public Works -State Police	Implementation $35,000 Operating Nominal to DPW, but State Police incur real and/or opportunity costs directly related to time spent at enforcement.	On normal day, saving of 4.5 min. to users. 38% savings over general lanes, Up to 20 min. travel time loss to penalized violators.	Trip purpose Peak period home to work trips primarily	No data.	Vehicle Occup. Aver. increased by 6% — from 1.35 to 1.44. Bus Riders ~1,000 riders on 32 buses. No information if this represents an increased ridership figure	Total vehicle use increased during 2-hour AM peak by 500 cars, an increase of 10%	No data.

TABLE 2.7 cont'd) COMPONENTS AND IMPACTS OF SELECTED HIGH-OCCUPANCY-VEHICLE LANE PROGRAMS

				PROJECT EFFECTS					
Project and Geographical Setting	Project Description	PARTICIPANTS: Planning Implementing Financing	Implementing & Operating Costs	Travel Time Changes	Trip Purposes and Rider Characteristics	Passenger Modal Shifts	Change in Vehicle Occupancy and/or Change in Ridership	Change in Vehicular Use	Change in Annual VMT
Sept. 1969 Shirley H'way -Links Virginia suburbs to Washington,D.C. -3 lanes each direction -34,000 daily auto vehicles -109 buses during peak period.	1)From 1969 to 1975: 11 mi. built of 2 right-of-way lanes. Opened to buses and in Dec. 1973, to 4-person carpools. 2)Lanes reversable during 6AM-9AM and 4PM-7PM operating hours. 3)"Mixing Bowl" extension onto Washington streets. 4)90 new buses purchased for express service. 5)3 finge lots designated.	Federal FHWA, UMTA Regional WMATA WASHCOG State Va.Dept. of H'ways & Transp. Local -N.Va. Transp. Commission -D.C.Dept.of H'ways & Traffic	Implemention $43 million, + $4 million for buses. Operating $10,000 ann'ly exclusive of bus operations. $6.7 million ann'ly for bus operations.	Average savings of 17.5 minutes on lane, or 51% time reduction. Total bus trip time reduced only 26%.	Peak period work-trips served primarily. Mean income of bus users $16,000. Similar for carpoolers.	Bus Riders For riders previously making this trip: 55% single auto users 5% other auto. Carpoolers 25% former bus users.	Average auto -occupancy increased from 1.35 to 1.65, 22% increase. +175% buses +196% bus riders Total:16,000 +33% increase in carpoolers Total: 4,600	+65%	VMT reduction of 46.5 mill miles.
Jan. 1973 San Bernardino Freeway -Links eastern suburbs to Los Angeles. -4 lanes each direction -30,000 vehicles use freeway during peak periods.	1)2 exclusive bus lanes; one each direction, built on RR right-of-way for 11.2 mi. No lanes removed from freeway. 2)24-hour operation. 3)Eastern bus terminal built; 2 on line stations, and 1 ramp entrance along busway. 4)1,400 park & ride spaces at bus terminal; 4 fringe lots designated elsewhere.	Federal FHWA, UMTA Regional SCRTD, SCAG State CALTRANS Local -City of L.A. -City of El Monte Other -Southern Pacific RR.	Implementation $57 million Operating Not available. Federal gov't provided 84% of implementation costs.	Bus lanes reduce line haul trip time by 13%. But 87% riders increase total trip time 3 to 30% by using buses rather than autos. Only 13% reduce trip time on buses, some by as much as 25%.	Trip purpose Peak periods: 92% work Aver. income of bus riders $17,500 Main reason for using busway are lower costs. Aver. savings of $1.00 per trip.	Bus Riders 50% single auto drivers 13% drive with passengers. 11% auto passengers 10% other transit	No effect on auto occupancy(1.24) Total bus ridership +700%, total:14,500. Total peak period bus ridership +900%, total: 19,000	No significant change.	VMT reduction of 19.3 milli miles.

TABLE 2.7 (cont'd) COMPONENTS AND IMPACTS OF SELECTED HIGH-OCCUPANCY-VEHICLE LANE PROGRAMS

				PROJECT EFFECTS					
Project and Geographical Setting	Project Description	PARTICIPANTS: Planning Implementing Financing	Implementing & Operating Costs	Travel Time Changes	Trip Purposes and Rider Characteristics	Passenger Modal Shifts	Change in Vehicle Occupancy and/or Change in Ridership	Change in Vehicular Use	Change in Annual VMT
December 1970 I-495 Approach to incoln Tunnel -Links New Jersey suburbs to Manhattan CBD 3-lanes each direction 2,300 passenger cars eastbound during AM peak hour 483 buses and 21,000 passengers eastbound during AM peak period	1)2.5-mile contraflow bus lane between N.J. Turnpike and Lincoln Tunnel 2)Lane operates 7AM-10AM eastbound to New York City 3)Buses enter lane off Turnpike via separate ramp 4)Instituted a park-'n-ride lot near Turnpike entrance	State N.J.DOT N.J. Turnpike Auth. Regional -Tri-State Regional Planning Comm. -Port Authority of NY/NJ (operator of lane and tunnel.	Initial Implementation $634,000 Capital Construction $1.4 million Operating $200,000/year Port Authority bore implementation costs NJ/DOT (2/3) and Port Auth.(1/3) shared operating costs	Bus Lane Saving of 7.75 min. on lane Total time 54% of bus riders surveyed felt lane saved 10-19 min. on total trip	Primarily work-trips.	Ridership pre-mode split: 81% continuing patrons 9% from other buses 4% auto 3% rail 3% did not make trip	Bus traffic increased 27% to 1,050 during peak period. Ridership also increased 27% to 44,100	Automobile use increased by 10%	No data.
March 1976 anta Monica Freeway* Links Harbor F'way and San Diego F'way in City of Los Angeles 4-lanes each direction 6AM-10AM: 28,600 vehicles east; 24,450 west 3PM-7PM: 27,650 vehicles east; 28,250 west	1)12.6 miles of with-flow bus and carpool lane in each direction. Use existing left-hand lanes 2)Both lanes operate 6AM-10AM and 3PM-7PM 3)3 person carpool minimum	Federal UMTA State CALTRANS Regional SCAG SCRTD Local -County of L.A. -City of L.A. -County of San Bernardino	Implementation $70,000 Evaluation Grant $800,000 (from UMTA) Operating Costs Not available	Non-preferential Lane Users Total travel time increased by 17% Freeway Entrance Ramps Wait time increased by 28% to 5.8 min.	Primarily work-trips	Not available	In April 1976: Total vehicle occupancy(buses & autos)in AM increased from 1.12 to 1.26. Carpools increased by 144%. Bus riders increased by 106%.	In April 1976: Total AM highway vehicles:86.5% of pre-lane count. Total AM highway passengers: 97.4% of pre-lane count. Total AM HOVL vehicles: 18% of pre-lane count Total AM HOVL passengers: 81% of pre-lane count.	Not available

* Discussed in detail in the separate report on City Studies.

TABLE 2.7 (cont'd) COMPONENTS AND IMPACTS OF SELECTED HIGH-OCCUPANCY-VEHICLE LANE PROGRAMS

				PROJECT EFFECTS					
Project and Geographical Setting	Project Description	PARTICIPANTS: Planning Implementing Financing	Implementing & Operating Costs	Travel Time Changes	Trip Purposes and Rider Characteristics	Passenger Modal Shifts	Change in Vehicle Occupancy and/or Change in Ridership	Change in Vehicular Use	Change in Annual VMT
May 1971 Southeast Exp'way -Links Boston to southern suburbs -3 lanes each direction -used daily by 105,000 vehicles -10,000 vehicles northbound during AM peak -57 buses during AM peak.	1)8.4 mile contra-flow bus lane. 2)Original AM and PM operation, became AM only in 1972 — 6:30AM to 9:30AM 3)Operated April thru October only. 4) Ended in 1976. To be replaced by withflow bus/carpool lane in the indefinite future.	State -Dept. of Public Works -MBTA during initial planing (no MBTA buses use lane)	Implementation $40,000 Operating $135,540 ann	Buslane time -14 min. Withflow lanes -4.5 min.	Trip purpose Peak period home to work trips primarily	Possible shifts of some person-trips to new competing rapid transit link. No data on shifts, if any to buses.	Vehicle occupancy declined from 1.48 to 1.43 Number of buses utilizing S.E. Exp'y increased by 14% but no information if these are new bus runs, or old switching routes	Vehicular use remained constant	No data.
Oct. 1971 Long Island Expressway -Links Queens and L.I. suburbs to Midtown Tunnel & Manhattan. -3 lanes each direction -3,800 auto v'cles enter Tunnel during AM peak hour. -158 buses use L.I.E. during AM peak periods.	1)Contra-flow express bus lane for 2.2 miles before entering tunnel from Queens. 2)Operates 7AM-9AM.	Local -N.Y.C. Transportation Adm.	Implementation $44,000 Operating $150,000 ann'ly	Buses save average of 9 minutes on lane, or 33% reduction in line haul time. Total bus travel time reduced by only 19%.	Bus Rider Trip Purpose 97.7% work .9% school Average income of bus riders is $17,640, some 28% more than aver. income of areas served by express buses.	90% of bus riders are former users of other transit. 5.5% auto drivers 2.6% were auto passengers.	Number of both express buses and riders increased by 44% (230 buses carrying 10,000 riders) No data on change in auto occupancy.	No data.	No data.

APPENDIX C

City Reports

CITY I: BOSTON, MASSACHUSETTS

Transportation Control Plan

The Transportation Control Plan (TCP) presently in effect for the Boston metropolitan area basically depends on five strategies:

(1) a light and medium emission inspection system,

(2) on-street parking prohibitions, including resident parking-sticker exemptions and a freeze on commercial parking,

(3) mass transit incentives, including wider distribution of the Massachusetts Bay Transportation Authority (MBTA) rider-pass,

(4) a computer-matching/employer-based carpool program, especially geared to firms with 250 or more employees, and

(5) a high-occupancy vehicle lane (HOVL) expansion program.

The parking restrictions represent a far less stringent version of the original order which reduced existing off-street parking by 25 percent. In a few cases, employers organized carpool programs and actually sought to attain the 25 percent objective; but, in general, the order was ignored by most Boston area employers. The computer-matching/employer carpool requirement is now being implemented as the Commonwealth's MASSPOOL program incorporating the handful of previously existing firm-based carpool efforts. MASSPOOL has also undertaken HOVL planning and implementation, paring down 11 feasible corridor studies to one corridor project which is scheduled to commence sometime in the Summer 1976 - Spring 1977 period.

HOVL Programs

Southeast Expressway

1) Background and Operations. In May 1971 an 8.4-mile section of the Southeast Expressway became an exclusive bus contra-flow lane during the peak-hour periods. Because of existing traffic patterns and safety considerations, particularly after a fatal accident involving a member of the work-crew, the evening reverse lane was discontinued the following year. The morning lane operated through 1975, but only in favorable weather and only between April and October.[1]

2) Project Costs. The lane was implemented by the Massachusetts Department of Public Works at a cost of $40,000 initially, plus $550 per day or about $70,000 annually for lane set-up and breakdown. Funds were provided solely from the Commonwealth.

3) Impact on Traffic. The lane provided a 14 minute time-savings to buses, equal to a 58% reduction for travel time spent on the Expressway between Quincy and just south of the Massachusetts Turnpike. Despite the line-haul time savings, bus ridership grew only 39 percent compared with a 66 percent increase in the number of buses utilizing the Expressway during the morning 6:30AM to 9:30AM peak-time. No insight exists as to whether the increase in buses was due to new service or the

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[1] November through March were dropped as winter months with often icy road surfaces. It is common for HOVL operations to be closed in bad weather unless they are permanently separated roadways.

[2] Shaded areas on maps in this section encompass Boston and the surrounding inner-ring suburbs.

rerouting of existing express buses. At the time that bus ridership increased, vehicular with-flow traffic remained at a constant pre-implementation level.

4) Future Operation. Since a with-flow carpool and bus lane is scheduled for the same section of the Southeast Expressway (see end of this section), the contra-flow lane was not re-opened in April 1976. Lengthy delays in the implementation of the new HOVL may, however, eventually cause the original bus lane to be reimplemented.

I-93 (North of Boston)

1) Background and Operations. Opened in two stages during 1974 to its final length of 1.4 miles, I-93 North is an exclusive bus and carpool lane located on the lower southbound level of the I-93 two-level Bridge in Charleston. One lane out of four is designated for three-person carpools and buses for the 6:30AM to 9:30AM period on weekdays.

2) Project Costs. Implementation costs of the I-93 bus and carpool lane have been roughly estimated to be $35,000 and are taken from state-budgeted funds to the Massachusetts Department of Public Works (DPW). Operating costs, exclusive of enforcement, are not available but are probably below those of the Southeast Expressway project. Real and opportunity costs of stationing a police officer at a particular point for the duration of the lane's morning hours are absorbed by the State Police Department. Enforcement has been a periodic problem, but an agreement has been reached with the State Police Department to have personnel present unless an emergency arises elsewhere. The method used to discourage non-carpool cars is to direct offenders off of the bridge and into the heart of Charlestown congestion.

3) Impact on Traffic. The lane has reduced travel time for carpools and buses by 38 percent (about 4.5 minutes) over the 1.4 miles while allowing head-of-the-line privileges to users once the lane is terminated. During the 7AM-9AM peak hours, 500 carpools and over 1,000 bus riders on 32 buses utilize the lane, the latter representing a 113 percent increase in both the number of buses and ridership prior to lane implementation. (Pre-implementation carpool counts were not recent enough for valid comparison.) The average occupancy during the peak hours increased from 1.35 to 1.44, although at the same time, total vehicular use has risen more than 9 percent -- a traffic volume increase seen as typical for highways in the area.

4) Future Operation. Since it is perceived as successful by both government agencies and the public, the I-93 HOVL is expected to continue under present operating arrangements.

Future HOVL Projects

Section 52.1139 of the same TCP regulations that led to the formation of MASSPOOL called for feasibility studies to be performed on incentive measures involving preferential bus and carpool treatment along 11 corridors in the Boston region. In response, MASSPOOL officials and the DPW intended to establish in May 1976 a with-flow bus and carpool lane along the same general length of the Southeast Expressway that the contra-flow lane previously occupied. During the 6:30 to 9:30AM peak-period, the left lane was to be physically reserved (utilizing signs, roadway lines, and insertable cones) for three-person carpools and buses, while nonpriority vehicles were to utilize the other two lanes and the shoulder. In addition, at least two lots were to be leased to serve as park-and-ride and carpool staging facilities. Other lots were expected to be used unofficially. MASSPOOL also expected to run a special carpool matching campaign for corridor residents although the details have not been made final. The decision to initiate this project has become a politically sensitive topic, and the issue has been sent to the governor for a decision.

Officials cite the need for reconstruction of almost the entire Southeast Expressway as one reason this route was chosen to fulfill the TCP regulations.[1] Present levels of vehicular use have to be reduced since entire lanes of the roadway will be removed for rebuilding. Currently, some 6,500 vehicles utilize the four northbound lanes, including the shoulder, during the morning peak-hour Expectations are that the exclusive lane will produce a 12 percent reduction of vehicles, including a possible 300 percent growth in carpools to 750 per hour, and a 30-40 percent growth in bus ridership (from the present 2,000 per hour to 2,600-2,800 per hour) accompanying a 50 percent increase in the number of buses. Nonpriority lane traffic is expected to remain stable. Overall, average vehicle occupancy, exclusive of buses, is expected to rise from 1.33 to 1.45.

On-highway costs of the project will exceed $14,000 for initial implementation, and subsequent costs will average about $70,000 annually for operations. The cost of park-and-ride lots totaling 375 spaces would be roughly $24,000, with an additional $25,000 required if security personnel are considered necessary at the lots. Posting signs at all lots is expected to cost $1,000. All lane-related costs are to be paid out of Commonwealth funds, but the costs of special carpool matching may be shared between federal and state sources. The Southeast Expressway was recently designated an interstate highway (I-93) and indications are that the costs of reconstructing the roadway may be paid on a 90:10 matching basis with the Federal Highway Administration.

Carpool Programs

MASSPOOL

1) Background and Organization. MASSPOOL, a statewide effort to increase carpooling among journey-to-work travellers, was initiated in Fall 1975 as the Commonwealth's response to Section 52.1138 of the EPA-promulgated State Implemention Plan

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[1] Attanucci; Fitzgerald.

dealing specifically with the Boston Transportation Control Plan. Coordinated by the Massachusetts Executive Office of Transportation and Construction, MASSPOOL has set as its target population all firms in the Boston Metropolitan Region, as well as in other major areas of the State with 250 or more daytime commuting employees. To effectively reach, match, and pool these commuters, MASSPOOL representatives will personally visit the firms to explain the program's objectives, distribute materials, including grid-location maps and questionnaires, and offer Commonwealth computer facilities for matching. Information gathered from completed employee questionnaires on residential location and work schedules is used to generate intra-firm carpool matches only. In areas such as industrial parks, where a number of firms have a common location, inter-firm matching becomes possible.

Since the program began only in late 1975, it is premature to project expected results. In the Boston region, MASSPOOL's program was initially expected to include over 1000 firms, but officials now expect somewhere between 600 to 700 employers to be involved. Participant firms are required to provide MASSPOOL with 6-month reports which indicate the impact of the program on the mode choice decisions of their employees. As of early 1976, some 140 firms have submitted 'base data' reports specifying existing, pre-MASSPOOL mode splits of their employees as summarized in the following table:

		Percent of employees			
Mode	Number of Employees	All Firms	City of Boston	Inner Ring[1]	Outer Ring[1]
Single-Occupancy Auto	49,505	41%	32%	58%	74%
Carpool	19,711	16%	15%	22%	22%
Vanpool	199	---[3]	---	---	.5%
Mass Transit	40,863	34%	45%	12%	.2%
Walk	5,847	5%	6%	4%	.8%
Other[2]	3,025	3%	2%	3%	2%
	119,150	100%	100%	100%	100%
TOTAL		--	86,380	14,263	18,507

[1] Inner and outer rings defined on MASSPOOL grid mpas. Inner ring excludes Boston and extends slightly beyond Route 128. Outer ring extends far beyond the I-495 belt in all directions.

[2] "Other" includes bicycle and motorcycle modes, as well as employees who use their automobile during the day for work related reasons.

[3] Too small to report.

2) Program Costs. The annual MASSPOOL budget of about $600,000 is being paid by a two-year 90:10 matching agreement between the Federal Highway Administration and the Commonwealth under the provisions of the 1974 Emergency Highway Energy Conservation Act. In addition to these costs, which cover the program's implementation as carried out by two outside consulting firms, approximately 30 percent of the time of a senior transportation analyst in the State's Office of Transportation and Construction is involved with MASSPOOL. Roughly one person-day a week is also provided by various personnel of the Massachusetts Department of Public Works. The analyst's salary, however, is paid by the Urban Mass Transportation Administration under an unrelated grant.

3) Program Impact. Despite the early stage of the program, MASSPOOL officials feel that the initial goals of a 25 percent reduction in regionwide work-trip VMT is unattainable; and, at best, a 1 to 3 percent reduction in journey-to-work trips and VMT in the Boston region can be expected. The lowering of expectations accounts for,among other factors, the increase in non-work trips that results when a car is left at home where it can be used by other family members.

In addition, ten firms, each identified by MASSPOOL as having existing carpooling rates well above the national average of 25 percent of the firm's work force, reported the belief that the program would have little effect since a "carpool saturation level" had been reached. Only significant changes in exogenous elements, such as gasoline prices or parking fees could possibly induce a sizeable change in carpooling.

Concerns of various officials that increased carpooling in the downtown Boston area would come at the expense of transit ridership has led MASSPOOL officials to postpone their efforts in dense employment locations well served by transit, such as the Government Center area. The previous table indicates that almost half of the employees working in Boston use mass transit for commuting. Though the average automobile occupancy is higher for work-trips into Boston than for trips to suburban work locations, carpools carry a higher percentage of total suburban employees -- i.e., in the absence of suitable transit service, paratransit options are used more heavily, while the reverse is true for the CBD area.

4) Future Prospects. The MASSPOOL project is presently scheduled to operate for a two-year period, at which point its success will be reviewed and the nature and scope of future matching efforts will be established.

Case Examples of Firms in the Boston Area

The following five employers were selected by MASSPOOL staff members as examples of ride-sharing programs at a variety of locations throughout the Greater Boston area. The principal selection criteria was that each firm already had some carpooling experience, but they also appeared to provide a representative cross-section.

John Hancock Mutal Life Insurance Company (Boston).

Location: Downtown Boston, Massachusetts.

Transit Service: Excellent rail and bus service.

Number of Employees: 6,500

Type of Program: Manual matching by use of zip-code lists; ads in in-house paper.

Date of Implementation: First efforts in 1940's; nine formalized programs set up in December 1973.

Costs: $25,000 annually for transit and carpool support efforts.

Change in Mode Split: Little impact due to already high carpooling level based on long history of ride-sharing efforts.

With a carpooling program that dates back to the late 1940's, John Hancock's Boston headquarters has had lengthy experience in the promotion of transit use and ride-sharing. A December 1973 survey of its 6,500 employees showed that only 11 percent of the work force were single-passenger car travelers, with an average automobile occupancy of around 2.0 for all cars and 3.1 for carpoolers. By October 1974 however, average occupancy had fallen to 1.8 and 2.7 for all cars and carpools respectively.[1] Even though carpool matching procedures were more formalized with the advent of the energy crisis, and transit use was supported by publicizing park-and-ride lots for express bus passengers in January 1974 and taking part in MBTA's prepaid transit pass program (February 1974), the employee mode split changed little between 1973 and 1975. The "Commuter Services Unit" at John Hancock felt this was due to the efforts by the firm to support ride sharing and transit use since the late 1940's. The unit's coordinator said that the 1200 employee parking spaces are presently all assigned with a waiting list that gives preference to carpoolers, but many employees park in surrounding parking facilities. John Hancock also shares matching lists (printouts of employees' residences by zip code area) with Liberty Mutual and New England Life, both having offices adjacent to the Hancock building. The firm made a rough estimate of $25,000 for the annual cost of the Commuter Service Unit. This only included the salaries of its two employees, but the coordinator felt that the additional expenses (materials, computer time, etc.) were minimal since they usually were "add-ons" to personnel office activities that would occur even without the commuter program.

Factory Mutual Company (Norwood, Massachusetts).

Location: Suburbs

Transit Service: Poor.

Number of Employees: 900

Type of Program: Manual matching by use of zip-code list; reduced parking spaces 25%.

Date of Implementation: Summer 1973

Costs: No estimates made, but seen as very low.

Change in Mode Split: Early 1973; 62% drive alone, 38% carpool
October 1975; 54% drive alone, 46% carpool

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[1] The survey instrument did not include any actual measure of the number of cars driven and included a "carpool driver/rider" mode that made estimation necessary, e.g. average occupancy of all cars in October 1973 was actually in the 1.78 to 2.30 range.

Located in a suburban town about 17 miles from downtown Boston, this firm in mid-1973 began to encourage carpooling among its employees through the creation of a computerized list (by zip-code area) of interested employees from which manual matching could be performed. Due to the high turnover rate among its 900-person work force, the list is updated every month.

In response to Section 52.1135 of the 1974 Transportation Control Plan (since revised) requiring a 25 percent reduction in firm-provided employee parking spaces, Factory Mutual roped off one quarter of its spaces. No preferential parking for carpoolers is offered, and the ample remaining free spaces in the firm's lot, plentiful spaces on surrounding streets, and the large number of "field" employees who do not park every day remove any constraint on automobile use. Before the program began, 62 percent drove alone and 38 percent came in carpools. By October 1975, single passenger cars had been reduced to 54 percent while carpooling went up to 46 percent. (No employees use transit, since service is virtually nonexistent.) The carpool rate was already well above what MASSPOOL considers as its "target" level. No estimate of the cost of the firm's carpooling efforts were available, but the coordinator's feeling was that costs were low, since no sophisticated matching system was used and staff costs were minimal.

General Dynamics Corporation (Quincy Shpyard).

Location: Outskirts of suburban coastal town.

Transit Service: Poor for most employees.

Number of Employees: 5,000 (3,500 day/1,500 night); five-year range from 7,500 (1970) to 2,300 (1973).

Type of Program: Manual matching by use of zip-code list.

Date of Implementation: Early 1970

Cost: No estimates made, but marginal costs seen as very small.

Change in Mode Split: No before *vs*. after surveying done; rough estimate of 36% of work force riding in carpools.

In response to the employee-related traffic congestion at the plant-site, General Dynamics began their drive to boost ride-sharing in 1970 when employment in the last five years has ranged between 2,300 in 1973 to around 5,000 in January 1976 with 3,500 on three staggered day shifts (starting 7:30AM, 8:00AM, and 8:30AM). A computer run of all employees by shift and zip-code residence location is made available for manual matching by people interested in forming or joining carpools. No "base" data were available to provide a basis for "before *versus* after" effectiveness criteria, but the personnel office estimated that roughly 36 percent of day shift employees traveled in carpools. No night shift data were available, but General Dynamics felt that the 1500 evening employees had a similar carpooling pattern. Parking at the yard is free and ample with over two spaces per employee. No carpool program cost information could be determined, but the rather low-key, "passive" nature of the program would require fairly small additional expenses. In one discussion, government officials described employee participation as exceptionally vigorous, to the point of individuals operating (illegally) private bus service to the shipyard. Transit service to the shipyard is considered poor for most employees.

Sun Life Assurance Company (Wellesley, Massachusetts).

Location: Suburbs.

Transit Service: Poor.

Number of Employees: 370

Type of Program: Passive matching by use of questionnaires, location board, carpool meetings.

Date of Implementation: January 1974.

Costs: No program cost estimates made.

Change in Mode Split: Portion of employees carpooling increased from 27% to over 40%.

Located in an area with no suitable transit service, faced with a shortage of parking spaces for its 370 employees and spurred on by the energy crisis, this firm began a carpooling program in January 1974. Using the intra-firm newspaper as a publicity tool and employee contact point, those interested in carpooling filled out questionnaires based on a 44-grid residential location system. A "carpooling week" initiated the program with informal meetings of interested commuters grouped by location and supported by lists of employees and carpools and a locator map. Through these efforts, carpooling was increased from 27 percent to over 40 percent with a goal of possibly 50 percent by the end of 1976, as well as raising the carpool occupancy rate. The commuter program's director also stated that the firm was interested in vanpooling, since projected expansion in its labor force would make parking facilities inadequate and vanpooling might save parking space constuction costs, as in the case of the 3M Company program in St. Paul, Minnesota.

U.S. Department of Transportation (Cambridge, Massachusetts).

Location: Downtown urban location in Cambridge, Massachusetts.

Transit Service: Good

Number of Employees: 700

Date of Implementation: March 1974.

Costs: No cost data collected, but seen as very low.

Change in Mode Split: March '74 - October '75: carpooling unchanged at 36%, but drive-alone mode up from 30% to 36% while transit dropped from 29% to 24%.

A regional office of U.S. DOT in the Kendall Square area of downtown Cambridge with close to 700 employees has had a matching program in effect since March 1974. Carpool application forms are filled out by interested employees using the normal grid system, but without any computerized matching. The staff members dealing with the agency's transportation survey and ride-sharing programs stated that carpooling had been relatively steady in the last few years with surveys in March 1974 and October 1975 both showing 36 percent of commuters riding in carpools. Single-passenger car travel, however, had increased from 30 to 36 percent, while transit use dropped from 29 to 24 percent. These changes are seen as an impact of the 1973-74 energy crisis, which lowered single-passenger use and increased mass transit use in the first quarter of 1974. Numerous surveys of DOT employees in the Cambridge office over the last 3 years have consistently shown that single passenger car and carpooling employees each comprise from 30 to 36 percent of total commuters, while transit users have comprised 24 to 26 percent, with the remaining 4 to 5 percent using other modes (walk and motorcycle dropped). No data were available on the cost of these surveys or of the agency's overall carpool program, but such non-computerized, "passive" matching systems tend to have relatively low costs. The person responsible for the agency's efforts did feel, however, that MASSPOOL would have almost no effect on its carpooling rate since DOT's 36 percent carpooling rate was already well above the 21 percent average for firms in Cambridge (based on MASSPOOL data from 17 Cambridge firms in late 1975), and seemed to be at the carpool "saturation point."

CITY II: WASHINGTON, D.C.

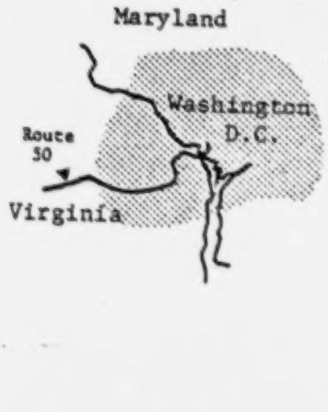
Transportation Control Plan

Some provisions of Washington's Transportation Control Plan (TCP) have been blocked by court action, but those now in effect include (a) a bus lane expansion program, (b) an expanded fleet of buses for the WMATA, the area's transit operator, and (C) and areawide carpooling effort. The bus lane strategy has been accepted by the District of Columbia, the State of Maryland, and the State of Virginia. To date, however, the only existing high occupancy vehicle lanes (HOVLs) are (1) the widely publicized Shirley Highway and its connecting streets in the District, (2) a maze of reserved curb lanes for buses in Washington, and (3) the Arlington Boulevard/ Route 50 bus lane in Virginia.

The carpool promotion program is being implemented by the Washington Council of Government; but, since the TCP does not make the carpooling program mandatory for firms, its efforts do not carry legal force. The following case studies examine the circumstance surrounding both the HOVL and carpool programs.

HOVL Programs

Arlington Boulevard (Route 50, Virginia)



1) Background and Operations. In November 1974, the Northern Virginia Transportation Commission and the Virginia Department of Highways and Transportation designated 4.3 miles of Arlington Boulevard/Route 50 as an exclusive buslane. This four-lane undivided highway southwest of Washington carries peak-hour commuter traffic between northern Virginia and the

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capitol City area, where the HOVL extends to within 3 miles of the Potomac River. Using rebuilt shoulders, the lane is open to express and local buses as well as right-turning vehicles, eastbound between 6:30AM and 9:00AM and westbound between 4:00PM and 6:30PM. Pullout areas allow local buses to stop out of the lane of traffic. Enforcement of the lane, which is not physically separated from the rest of traffic flow, is provided by county police on a part-time basis.

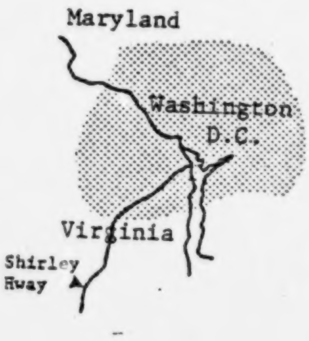
2) Project Costs. Implementation costs of the Arlington Boulevard exclusive bus lane were high, with over $1.2 million being spent on construction alone. Operating costs, on the other hand, have been slight. All costs are paid from state funds normally allotted to the Department of Highways and Transportation.

3) Impact on Traffic. Only 24 buses use the entire lane during each peak period, the same number that used the same route before the project began although 13 other buses use a portion of the lane. The average time savings of buses using the entire length of the lane is almost 2.5 minutes, or a 17 percent reduction in travel time. Counts collected in the fall of 1975 indicate that ridership on the 24 through-buses increased by 10 percent since the project began. Average bus occupancy grew by the same amount -- to almost 46 passengers per bus -- indicating to the Northern Virginia Transportation Commission (NVTC) officials that the potential for increased demand existed if the bus fleet supply could be increased. No information is available on the effect of the exclusive lane on automobile traffic.

4) Future Operations. Though the success of the lane has been rather limited, no changes in the structure or method of operations of the HOVL are scheduled.

Shirley Highway (Virginia)

1) Background and Operations. The Shirley Highway Buslane, between the suburbs of Virginia and Washington, D.C., is a permanently constructed busway that is physically separated from the rest of the highway. It opened in 1969 with a five-mile



section of two peak-period reversible lanes. The length has subsequently been extended to 12 miles under the joint auspices of federal, state, regional and municipal governments. In addition to the roadway, the project included new bus routes, buses, designated park-and-ride areas, and bus shelters.

2) Project Costs. Since HOVL construction was part of the overall program to raise the Shirley Highway to inter-state highway standards, the average $4.1 million per mile construction costs were shared on a 90:10 matching basis between FHWA and the State of Virginia. An additional UMTA grant to the Washington Metropolitan Area Transportation Authority and the Northern Virginia Tranportation Commission -- which administers the bus lane along with the Virginia Department of Highways and Transportation -- provided $5.6 million toward transit expansion and improvement. Operating expenditures for the roadway are $10,000 annually, covering the daily lane switch-over operations from north to southbound direction. Bus operations, which averaged nearly $1.8 million during the 1971-74 period, are now part of the overall WMATA budget.

3) Impact on Traffic. Buses average a 17.5 minute time savings on the lane, or a 51% reduction in line-haul time compared to a 26 percent decrease in overall total trip-time. Bus patronage exceeded 14,000 in 1975, a growth of more than 150 percent since 1969. Ridership suffered a drop in December 1973 when four-person carpools were allowed to use the lane. Almost 25 percent of total carpoolers were former users of buslane transit vehicles. Although auto usage levels are 18 percent less than anticipated without the project and automobile occupancy rose from 1.35 to 1.65, automobile travel on the Shirley Highway during the peak-period has still grown 65 percent. Project officials estimate a daily VMT savings of 186,000 miles.

4) Future Operations. The number of HOVL entrances open to carpoolers was increased from two to three in March 1976 by opening the formerly bus-only Seminary Road ramp. There has been some discussion of reducing the minimum carpool size to 3 passengers, and even opening the HOVL to general traffic, but no actual changes in the lane's operation are presently planned.

Carpool Programs: The "Commuter Club" Carpool Program

1) Background and Operations. In response to the 1973 Transportation Control Plan which required a computer carpool matching service, the Council of Governments (COG), in association with the Metropolitan Washington Board of Trade (BOT), and the Federal Government's General Services Administration (GSA) established the "Commuter Club" in late 1973. The purpose of this operation is to provide centralized ride-matching services throughout the metropolitan area to those commuters who are interested in forming carpools. The majority of CC's efforts were concentrated on large public and private employers or groupings of smaller employers. Eventually, however, in 1976 the program was opened to the general public with applications available in banks and other public places as well as over the phone. All materials, questionnaires, and computer matching operations are provided at little or no cost to the employers in return for a minimal amount of intra-firm publicity for the program.[1] In the September 1973 to September 1975 period, over 800 employers were contacted through phone calls and site visits. Over 372,000 questionnaires were distributed -- 60 percent to the private sector and 40 percent to the federal and District of Columbia employees.

Another government regulation spawned by the energy crisis to boost carpooling was GSA's "90-10" rule which required government agencies to set aside 90 percent of their parking spaces for carpools. Two factors limited the impact of this action: (1) the requirement was only "conditional" when first introduced in early 1974 and was then designated as a "guideline," not a mandatory action when officially sanctioned in July 1974, and (2) it required that the 90-10 rule be met by the combined agencies rather than at each location, so that an agency could have only 20 percent of its carpool spaces in the CBD of Washington and 95 percent in suburban or rural locations with excess parking spaces. In general, GSA's rule seems to have had minimal impact on the carpooling rate of federal employees.

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[1] In CC's first year, private employers paid 25 cents for each questionnaire processed, but this charge was dropped.

2) Project Costs. During fiscal year 1974 COG operated the carpool program on a budget of approximately $60,000; these funds were originally assembled for the planning of a matching system, but the energy crisis of late 1973 forced COG into actually matching. The 1974 funding came from a $24,000 grant from the regional office of EPA, $24,000 from COG's transportation planning budget, and around $12,000 from assorted COG transportation funds. In this initial year of operation, a substantial amount of in-kind aid was received from the Northern Virginia Transportation Council (NVTC), BOT, GSA, and the District of Columbia. These agencies handled a large portion of the site visits and related follow-through, especially to the public sector employees. Until Fall 1974, NVTC had its own carpooling program ("Commuteride"), but since then has been a part of the Commuter Club program. BOT was very helpful in a liaison capacity with the private sector, and it also helped to cover printing costs in the program's first year of operation.

In fiscal 1975, Commuter Club's budget increased to $212,000 with funds provided equally from the Federal Highway Planning and Organization funds of Maryland, Virginia, and the District of Columbia.

3) Program Impact. The following results show the return rate of questionnaires handed out to employers:

	(a) # of Employees	(b) % Filling Out Questionnaires	% of (b) Who Were Matched	% of (a) Who Were Matched
Private employees	223,000	24%	78%	19%
Public employees	149,500	17%	89%	15%
Total	372,500	21%	82%	18%

The amount of follow-up data collected on the number of matched persons who actually joined pools was very limited; but based on a small sample of employees, CC's coordinator feels that 7 percent to 10 percent of those matched actually formed or joined pools. In terms of the overall target population, therefore, about 1 percent to 2 percent of all employees contacted were believed placed in pools.

Assuming that none of the new carpoolers formerly rode mass transit and that the average new carpool had three members, this would mean a maximum vehicle work-trip reduction of only 1 percent and a total trip reduction of much less for these employees. Due to the lack of data, more specific statements on the effectiveness of the program cannot be made, but it is clear that the impact on vehicle use was very small.

4) Future Prospects. The fiscal 1976 budget is $150,000 and a $100,000 budget is slated for fiscal 1977 with most of the funds for these two years aimed at updating the matching files. COG officials are hoping to receive additional funding from Region III of EPA for a vanpool program in the Washington area. The proposed vanpool program would provide interested employers with a full array of support mechanisms to aid the organization, implementation, and administration of an employer-based commuter vanpool program. The target population for this effort is expected to be large firms with somewhat limited parking and insufficient transit service. Since those areas with the highest "job per space" ratios in Washington, D.C.[1] tend to also have the highest transit use for work-trips,[2] a conflict between vanpools and transit would arise. COG personnel agree that this problem must be considered and it might be lessened by careful selection of vanpool sites.

Case Examples of Firms in the Washington, D.C. Area

The following nine employers were selected with the advice of the Commuter Club staff as a representative mix of public and private employers in both suburban and urban locations. As neither the employers nor the program's staff performed thorough follow-up analyses of the impact on mode split at these locations, the data are often "soft" -- a problem attributable to the voluntary nature of the program.

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[1] Metropolitan Washington COG, National Capitol Region Transportation Planning Board, Parking Management Policies and Auto Control Zones, Summary Report Draft (February, 1975), p. 15.

[2] National Capitol Region Transportation Planning Board, "Commuting to the Core," Information Report No. 33 (October, 1970).

Chesapeake and Potomac Telephone Company

Location: Two urban locations within District of Columbia

Transit Service: Fair to good

Number of Employees: 3700 combined total at both locations

Type of Program: Commuter Club's matching (23% filled out questionnaires)

Date of Implementation: Early 1974

Costs: No cost to firm

Change in Mode Split: No survey data collected. Firm believed carpooling was not affected by program.

Of its numerous locations throughout the Washington, D.C. area, only two offices of the Bell Telephone System's regional subsidiary were involved in the Commuter Club. Both operations are within the District of Columbia ("K" and "H" Streets), with a combined work force of over 3700. The portion of the total work force at these locations that submitted completed carpool questionnaires -- 23 percent -- was slightly below the average regional 24 percent figure; carpool coordinators at C & P, however, felt that the overall response to the almost 700 matching lists received was "poor" and "of little consequence to carpool formation." The employee complaint most often voiced concerning the matching program was that the grids used to specific residential locations were too large; switching from driving alone would, therefore, add prohibitive amounts of work trip travel distance and time to a prospective carpooler's daily commute. The success of both "word-of-mouth" and "ride wanted" ads in the in-house newsletter informing carpools was seen as much greater than the matching effort. The feelings expressed by the firm's representatives toward carpooling as an answer to congestion, energy, and pollution problems were rather pessimistic, with a stronger interest in expanded transit. Even though both C & P inner-city locations were fairly well served, they felt that the shortcomings of transit routes and scheduling kept transit's share of their employees' work trips at its present level of 10 to 15 percent. (No exact mode split data were available.)

Control Data Corporation (Rockville, Maryland)

Location: Outskirts of suburban town.

Transit Service: Poor

Number of Employees: 500

Type of Program: Commuter Club's matching program (30% filed questionnaires for initial matching, but only 5% filed in January 1976 update).

Date of Implementation: Spring 1974

Costs: $40 paid to COG for initial matching. No other costs.

Change in Mode Split: Believed carpooling had decreased from energy crisis peak, but no data were collected.

A data processing firm with roughly 500 employees in this regional office, CDC is located in a suburban area where a large number of firms and agencies are located. Many of the employees are programmers, systems analysts, and general administrators, who tend to have irregular work schedules that make carpool formation difficult. The firm's personnel office felt that CDC's overall "flexible work hours" policy may have been detrimental to the carpool drive. Though no actual survey data exist, firm officials felt that approximately 20 percent of the employees rode in carpools. Parking at this location is both ample and free with no preferential spaces for carpoolers. In its first experience with Commuter Club, 150 out of 500 distributed questionnaires were sub-itted for matching -- substantially more than for the 1976 update when only 25 out of 500 were returned. CDC has since established its own passive matching system using a printout of employees by residential location to aid employees in finding potential carpoolers in their area. Although no data existed on the change in carpooling since the Commuter Club program and their own in-house matching were implemented, the firm felt that carpooling had probably decreased from the energy crisis levels of early 1974, and that modal patterns would not change unless a similar crisis occurred. Transit service is poor in Rockville with only a handful of employees using it. Costs of the carpooling efforts have been minimal with around $40 paid to COG for the initial matching drive (when a 25 cents per questionnaire charge was in effect). The existing in-house program used personnel office employees and the in-house newsletter that already existed, and the employee printout was of little financial consequence to a data processing firm.

George Mason University (Fairfax, Va.)

Location: Suburban area

Transit Service: Fair to poor for most students and employees.

Number of employees: 600 employees & 4400 students.

Type of Program: Commuter Club's matching program (2.5% of campus population filed questionnaires).

Date of Implementation: Mid-1974

Costs: Minimal on-campus publicity costs.

Change in Mode Split: Matching data used by few persons; no mode split data collected.

Of all the employers who utilized the Commuter Club program, this university had the worst matching record. Out of a total population of roughly 5,000 (4400 students, 600 employees), only 125 questionnaires were submitted -- too few to even provide any matching lists. (A list of employees and students interested in carpooling was produced.) Members of the campus affairs office felt that the CC program had been well publicized on campus through flyers, posters and in the campus newspaper. Unfortunately, these efforts did not keep it from being "a real flop" in the words of GMU officials. The only group responding significantly was the custodial work force with most of its employees coming from a nearby town where transit service was poor. Wages were relatively low among its members. The university was able to convince local bus operators to bring three new bus routes through the campus, especially two that connected the campus with the town of Alexandria. The failure of the carpool program at this university does not mean that such institutions are not ammenable to carpooling, as the limited successful efforts at the Universities of Iowa[1] and Minnesota[2] have shown. The fact, however, that these two universities ran their own programs and provided more extensive intra-university support, especially at the Minnesota Campus, was probably critical.

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[1] M. Ahrendsen, L. Appelson, University of Iowa Carpool Matching Service: An Evaluation, Institute of Urban and Regional Research, University of Iowa (April 1975).

[2] K. Kozar, University of Minnesota Car Pool Service, Office of Physical Planning, Univ. of Minnesota (June 1974).

The GMU staff had no survey data to support their feelings, but they believed strongly that carpooling had already "run its course" at their institution. They had stronger hopes for even more expanded transit service, especially for their student population.

National Oceanic and Atmospheric Administration (Rockville, Maryland).

Location: Two in suburban Maryland and one in Washington, D.C.

Transit Service: Poor at suburban locations, good at D.C. site.

Number of Employers: 800 & 1350 at suburban sites, 700 at D.C. office.

Type of Program: Commuter Club's matching program (20% filled out forms, only 6% filed update forms).

Date of Implementation: Early 1974

Costs: None to employer.

Change in Mode Split: Carpooling up after initial month (suburbs only), but decreased as energy crisis subsided.

A subdivision of the U.S. Department of Commerce, this agency has five locations throughout the Washington, D.C. metropolitan area. The second largest site (1000 employees), located in Suitland, Md., participated in the carpool program of the Census Burea which has a facility in Suitland directly adjacent to NOAA's. Both agencies' facilities at this site are almost exclusively computer operations and therefore share the same personnel and working schedule peculiarities of such offices. Three other locations -- Silver Springs (800 employees), Rockville (1350 employees), and Georgetown (700 employees) -- also joined the Commuter Club program. Roughly 500 staff members worked at the fifth site in the Commerce Department's Federal Triangle office in downtown Washington, D.C.

The personnel division representative for NOAA felt that the Commuter Club had been very helpful and was immediately available at the time of the energy crisis. Cost to the agency was close to nothing. In the first matching effort, about 20 percent (approximately 500 out of 2500) of the Silver Springs, Rockville, and Georgetown employees filled out questionnaires -- around 18 percent higher than CC's overall results for public employees. Roughly 80 percent of the responding employees were matched, and it was felt that carpooling did increase noticeably, especially at the largest location (Silver Springs). The fact that transit use was fairly high at the Georgetown and Federal Triangle offices made both the energy crisis and the need for carpooling less important there. After the crisis subsided in Spring 1974, carpool interest and use declined. A carpool matching update in late 1975 had only 6 percent of the 2500 employees submitting questionnaires. NOAA felt that the over-18-month-time gap between initial and second matching efforts was the major shortcoming of the CC program. Any future carpool efforts would probably be in-house with monthly updates of carpool lists. Another energy crisis, especially one that not only raised prices but constrained gasoline supplies, was invisioned as a necessary exogenous factor for any expansion of carpooling.

Government Employees Insurance Company (Washington, D.C.).

Location: Fringe of Washington, D.C.

Transit Service: Fair to poor.

Number of Employees: 3000

Type of Program: No matching program, spaces reserved for 3+ person carpools; also has had buspool program since 1966.

Date of Implementation: November 1972

Costs: Approximately $10,000.

Change in Mode Split: # carpools up from 218 (11/72) to 280 (1/74) and settled at 240 (10% increase over 11/72 level).

GEICO's national office employs about 3000 persons at facilities on the D.C.-Maryland border and has been discouraging automobile drivers from driving alone for more than a decade. It began a buspool program in 1966 that now carries 10 percent of the work force aboard privately operated commuter buses, some traveling over 40 miles one-way. This program, however, has not relieved the overutilization of the firm's free employee parking lot, leading to initiation of a carpool incentive program in November 1972. The major component of the program is the reservation of some employee parking spaces for three-person or more carpools. Participating carpools display a card on the dashboard which is checked daily by a parking attendant, who additionally records the number of persons in the automobile to ensure that the three person minimum is met at least three out of five days weekly. GEICO has not provided computer matching for its employees nor has it been involved in COG's Commuter Club program. It does, however, provide weekly displays of ride and rider wanted information on bulletin boards. Daily carpool monitoring shows that the number of carpools rose to a peak of 280 in late 1973-early 1974, representing a 28% growth over pre-program figures. Carpool occupancy at that time was almost 3.6, or a third of the firm's employees. Since that time, carpooling has leveled off to about 240 in early 1975, representing only a 10 percent overall gain in carpools compared to November 1972. The occupancy rate has remained constant at the peak period level. GEICO officials have no exact estimates of the program's costs, but they indicate that it is operated by one full-time clerical person (approximate salary of $6000) plus a minimum amount of one administrator's time. The parking attendant was employed in that position prior to the program's implementation.

University of Maryland (College Park, Md.)

Location: Inner suburbs of Washington, D.C.

Transit Service: Fair to poor.

Number of Employees: 8000 employees & 16,000 commuting students.

Type of Program: Commuter Club's matching program (student) and their own computer matching service for employees.

Date of Implementation: Late 1973

Costs: Very little costs for Commuter Club program, $1200 annually for U. of Maryland's own program.

Impact on Mode Split: No measure of effectiveness; interest was high in crisis but much lower now.

The College Park campus located about 2 miles northeast of Washington, D.C. began encouraging carpooling in late 1973 as a participant member of the COG's Commuter Club program. Questionnaires were distributed to 16,000 commuting students, in their registration packets. Eighteen percent returned their questionnaires and sixteen percent (about 2600) were provided with matches. The University does not know how many of these students actually formed carpools. For its 8000 employees, the University simultaneously provided its own direct mailing, promotional, and computer matching services, at an approximate cost of $1200 yearly, most going towards the annual mailing of questionnaires.

Lists are still generated annually, but matches are not distributed to employees unless requested by visiting the carpool office on campus. At the height of the fuel crisis in early 1974, approximately 40 requests a month were made. Throughout 1975, the total was only about 50. Employee carpools are provided preferential parking spaces nearer their particular work location, although there is an ample supply of free parking for all employees. Officials estimate that between 500-1000 carpools are operating in 1976, although no actual counts have ever been conducted. Administration of the employee carpool program is handled by three persons on a part-time basis.

Mitre Corporation (McLean, Virginia)

Location: Industrial park on outskirts of Washington, D.C.

Transit Service: Fair to poor.

Number of Employees: 1000

Type of Program: Commuter Club's matching program followed by manual matching of list of employees by residence location.

Date of Implementation: Both done in early 1974.

Costs: Commuter Club program virtually free, Mitre's own effort seen as inexpensive.

Change in Mode Split: Presently estimate 25% are in carpools but no surveys made.

Located in an industrial park about two miles west of Washington, D.C. the Mitre Corporation has internally provided computer carpool matching services for its almost 1000 employees since 1974. Originally a member of the Commuter Club, the firm was dissatisfied with the program's inter-firm matching policy and the employee complaints about receiving outdated lists. Since then, Mitre has generated its own intra-firm lists with quarter-annual updates of employee home addressess grouped into city headings. Employees must contact the carpool office in order to obtain individual listings relevant to his or her location. Even though the list's availability receives minimal publicity and there is ample free parking for all, Mitre officials estimate that as many as 25 percent of the employees are carpooling. No actual figures, however, have been compiled. The costs of preparing the list of employees four times a year are considered marginal.

The Pentagon (Washington, D.C.)

Location: Inner suburbs of Washington, D.C.

Transit Service: Fair

Number of Employees: 25,000

Type of Program: Initially, Commuter Club's matching program, but eventually done internally; 60% of parking spaces reserved for carpools.

Date of Implementation: Early 1974 for Commuter Club program, Pentagon's own computerized matching in December 1974.

Cost: No cost data made available.

Change in Mode Split: Early 1974 had 300 registered carpools; presently about 5500 including some employees from local firms.

In response to the GSA 90:10 guidelines and a directive from the Defense Secretary, the Pentagon began a carpooling effort among its 25,000 occupants in late 1973 by designating 60 percent of its 10,000 space lot for two-person or more carpools. Of the remaining 4,000 spaces, 1200 were provided to the Bicentennial Administration to serve as fringe parking; and the rest were reserved for handicapped employees, educators, and visitors.

Choicest spaces within the designated area are given to the highest occupancy carpools; but, unlike other Federal Government carpool programs, grade or rank of employees has no bearing on the assigned carpool space. Carpool permits are reviewed every six months, and vehicles and spaces are monitored frequently by parking control officers. In addition, the Pentagon has provided computer matching since December 1974. The Commuter Club services were initially utilized, but eventually the matching was performed internally. Lists based on employee questionnaires are updated monthly, and matches are mailed to applicants directly.

Previous to parking/matching programs, some 360 carpools were officially registered with the Pentagon. In 1976, the number is officially stated to be between 5000 and 6000, with an average carpool occupancy of 2.6. Several hundred of these carpools include one or more persons not officially employed by the Defense Department, but employed by a nearby firm in, for example, Crystal City. Parking rules require only that one member of the carpool be a Pentagon employee, although no active inter-firm matching is undertaken. In addition to the carpooling, the Pentagon encourages but does itself operate commuter bus programs, which now carry over 2100 employees on private express lines from outside the WMATA region. Three van pools are also in operation.

Officials have no reliable indicators for the costs of the parking/matching carpool program, except that they are not considered large. Matching is merely a marginal service provided by Air Force computers and computer personnel. Administration of the parking area is a function falling to standing committees on parking matters and to existing personnel employed as parking control officers. Direct costs associated with promotion, distributing questionnaires, and mailing lists are not available.

National Aeronautics and Space Administration (Washington, D.C.).

Location: Washington, D.C.

Transit Service: Fair to good.

Number of Employees: 1550

Type of Program: Manual Matching (grid location map); assigned over 80% of parking spaces to carpools.

Date of Implementation: 1964

Cost of Program: No figures made available.

Change in Mode Split: No pre-program data available; presently over 70% of employees ride in carpools with average of 3.9 persons/car.

The carpool program at the NASA headquarters in Washington consists entirely of a restrictive parking policy following the guidelines set down by the GSA. Between 85 and 90 percent of the 312 spaces located in two garages and 50 percent of 35 spaces in one parking lot have been designated as exclusive carpool spaces. In the garages, those vehicles with five or more rides are automatically entitled to a space. Those with less are awarded spaces on the basis of points accruing from the number, the grade, and the years employed of persons in the vehicle. Officials estimate that only 15 applicants for a carpool space in either the garages or the lot could not be accommodated in 1975. Parking permits are reallocated semi-annually. Parking charges range between $10.80 a month for a garage space and $18.36 a month for the commercially oriented parking lot. A fairly recent count of carpools indicates an average carpool vehicle occupancy of 3.87, meaning that between 71 and 74 percent of approximately 1550 employees are carpoolers. No pre-program figures on carpooling are available.

CITY III: CHICAGO, ILLINOIS

Transportation Control Plan

The TCP (Transportation Control Plan) presently in effect for the Chicago Metropolitan Area depends on three basic strategies:

(1) A "light-duty" vehicle emission inspection system.

(2) Expanded on-street parking prohibitions in the downtown Chicago area.

(3) A permit system aimed at curbing the growth of off-street parking facilities.

In addition, a computerized traffic signalization system for the Chicago CBD, already studied and slated for implementation by the City of Chicago before the TCP regulations were released, was mandated in the December 1973 TCP with a completion deadline of June 1975. The only strategy that has faced strong political resistance is the inspection/maintenance regulation, while the other strategies are in the process of being implemented. A roughly $1 million contract to replace the 50-year-old traffic control system in downtown Chicago was awarded in April 1974, but changes in the software system has delayed its implementation until mid-1976. No-parking areas, "tow-away zone" restrictions, and short-term metered parking were put into effect on 10 Chicago CBD streets in November, 1975.

Carpool matching programs and HOVL developments were mentioned in the December 1973 TCP regulations along with off-street parking surcharges and park-and-ride facilities as possible "additional" strategies, but none was made part of the TCP. There have been and presently are, however, examples of the carpool programs and HOVL's in Chicago, as explained below.

HOVL Programs

Chicago CBD Contra-Flow Bus Lanes

1) Background and Operation. Of the 613 million transit rides taken on Chicago's mass transportation system in 1975 -- down from 784 million in 1966 -- bus passengers outnumbered rail-line riders by over three to one. This pattern is reversed for trips into the CBD "Loop" area, where rail transit plays and understandably larger role.

Table III-1

Distribution of Person Trips Into Chicago CBD by Mode (1974)

Mode of Travel	24 Hour Total		7:30 AM - 9:30 AM	
	#	Percent of Total	#	Percent of Total
Railroad	117,857	15.3%	89,584	29.7%
Subway & Elevated	228,869	29.6%	96,138	31.9
CTA Buses	105,224	13.6%	44,254	14.7
Out-of-town Buses	20,527	2.7%	3,296	1.1
(Transit Sub-Total)	(472,477)	(61.2%)	(233,272)	(77.4%)
Private Autos	229,088	29.6	54,848	18.1
Taxis	52,033	6.7	9,670	3.2
Other Vehicles	18,944	2.5	3,810	1.3
TOTAL	772,839	100.0%	301,600	100.0%

Source: Computed from data in 1974 Cordon Count: Chicago Central Business District. City of Chicago, Dept. of Streets and Sanitation. Data are for May 1974.

Table III-1 clearly shows the dominant role of transit in the CBD-bound travel. Transit's 77 percent share of peak period trips is second only to the 90 percent figure for the Manhattan CBD. The six commuter railroad lines carry almost 69 million annual passengers, with only the southwest corridor lacking railroad or rail transit service.

To help handle the 125,000 bus passengers entering the CBD area in almost 6000 buses every day, the City of Chicago has planned to establish contra-flow buslanes on four one-way streets in the heart of the downtown area. All buses traveling on four westbound and four eastbound streets will be placed on two westbound (Washington Street, Jackson Blvd.) and two eastbound (Madison and Adams Streets) contra-flow, curb lanes. A companion project -- an extensive pedestrian-bus mall running north-south along State Street -- has run into problems concerning federal funding, but it has substantial support from local business interests who see it as a way of curbing the flow of commercial activity to Michigan Avenue.

The principal physical problem with the lanes is that traffic engineers and planners in CTA (Chicago Transit Authority) and the City's Traffic Engineering Department were wary of possibly dangers to pedestrians expecting one-way traffic and stepping out into the bus lane. Visits and discussions with operators of existing CBD contra-flow buslanes (e.g., San Juan, Puerto Rico) and FHWA and UMTA officials are planned to identify methods to minimize this danger.

2) Project Costs. The costs of implementing the four contra-flow lanes are projected as follows:

Costs of Contra-Flow Buslanes in Chicago CBD

Engineering	$ 39,000
Construction	100,800
Electric F.A.*	48,719
Water F.A.*	2,517
Traffic Control	31,000
CTA Bus Signs	75,600
Misc.	10,000
	$307,636

Source: City of Chicago, Transportation Engineering Division, Department of Public Works

* Covers the cost of relocating electric and water pipes under the street surface.

The funding of the construction expenses for the buslane plan comes from Federal Aid Urban System Funds (70 percent) and City of Chicago Motor Fuel Tax (30 percent). The City is required to pay all engineering costs; so the eventual

City/Federal split would be roughly $110,000 City/$270,000 Federal. The relatively large construction costs are attributable to "curb cuts" at 4 intersections where added lane space is required for buses to turn onto the designated lanes. The lanes will not be physically separated by either permanent or temporary barriers or cones; a 2-foot wide painted median, no-turn signs on cross streets, and pedestrian warning signs will be used to delineate the lane and warn motorists and pedestrians. The traffic signal system will be adjusted to give 3 second lead time to buses to avoid conflict with left turns out of the opposing traffic flow. The lane is seen as partially self-enforcing.

3) Impact on Traffic. The transit service most likely to benefit from the CBD bus lanes is local bus service. Buses will no longer be required to avoid parked cars. Express buses, however, will not be able to pass local buses, which will reduce the time savings over travel on mixed traffic, one-way streets. Removal of bus traffic from four other streets should improve traffic flow on those streets, and the flow of opposing traffic on the four buslane streets is expected to be similar to that experienced before the 1974-75 parking restrictions.[1] Transportation planners in Chicago view these bus lanes as improving the overall management of the CBD street system rather than merely favoring bus over automobile travel. No basis for making even an order-of-magniture estimate of the impact on total VMT or vehicle trips was available, but any changes attributable to these four lanes would probably be very small.

4) Future Prospects. The institutional problem that presently is delaying the actual construction of the lanes is a conflict between the City of Chicago and State of Illinois. Frictions between the Mayor and Governor have caused delays, postponements, or cancellation of numerous public works projects in the Chicago area, the largest being

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[1] Before the restrictions, three of these streets had 2 moving lanes and 2 parking lanes. In effect, the lane opened to traffic through "no parking, towaway" restrictions will now be used for the bus lanes. Only one of the 4 streets (Washington Street) has 5 lanes, with 1 parking, 1 reverse-flow buslane, and 3 opposing traffic lanes.

the huge Crosstown Expressway Project -- a 22-mile series of highway links with a separate median-lane busway in certain portions. This expressway was projected to cost $900 million in 1970, but present estimates are in the $2 billion range. Using the leverage it has over the approval of FHWA funds for individual projects, the State has stated recently that it wants to administer the project, including the awarding of construction contracts which previously were to be handled by the City. If the State were to take over the project, a three-to-four-month delay would result because the project's internal arrangements would have to be revised to meet State rather than City specifications. Under any arrangement, the City would still supervise the actual construction. A letter was sent from the Region V Administrator of EPA to the State requesting that the project begin and pointing out the deadlines for the lanes' implementation as spelled out in the TCP. As of the end of April 1976 this problem remained unresolved.

Other Potential Expressway or Arterial HOVLs in the Chicago Area

The major limited-access roads entering Chicago are (1) Lake Shore Drive from the North & South, (2) Dan Ryan Expressway from the South, (3) Kennedy and Eisenhower Expressways from the Northwest and West respectively, (4) the Stevenson Expressway from the Southwest, and (5) Edens Expressway feeding into the Kennedy Expressway from the north. The Kennedy, Eisenhower, and Dan Ryan already have rail facilities in their right-of-way, and the Edens and Lake Shore Drive South are directly adjacent to commuter rail lines. Only the Southwest Corridor, with the Stevenson Expressway and Archer Avenue as the main commuter roadways, has no rail service,[1] and is presently the only corridor receiving serious consideration for a possible HOVL project.

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[1] The Illinois Central-Gulf Railroad runs one train per day into and out of Chicago. This train is filled to capacity, but the railroad cannot justify additional trains.

Stevenson Expressway HOVL

1) Background and Operation. In the morning rush hour, the Stevenson Expressway carries 5,300 vehicles per hour inbound with 18 percent trucks, and 4,200 outbound with 15 percent trucks. The balanced nature of the traffic rules out a contra-flow treatment on the Stevenson, but both the left- and right-hand with-flow lanes are presently being considered for HOVL implementation. The Archer-Stevenson routes into the Chicago CBD presently handle 108 heavily utilized buses in the two-hour morning peak-period; about one-third of these are using the Stevenson Expressway. Full-route trip-times average over 50 minutes, but frequent traffic delays can add 10 to 15 minutes.

The City of Chicago Department of Public Works, in cooperation with other municipal agencies, is presently involved in a "Southwest Corridor Carpool/Transit Study" to (1) inventory the existing transportation system supply and demand, (2) study alternative transportation improvements and carpool/transit programs for the corridor, and (3) produce plans and designs for actual construction and implementation. The project is funded at a $100,000 level, using transfer funds from the Federal And Urban Systems Funds as approved by the Energy Highway Energy Conservation Act of 1973. The principal methods being analyzed to reduce automobile travel and increase transit and paratransit use include (1) roadway alternatives, such as HOVLs on the Stevenson or a signal pre-emption system for buses on Archer Avenue, (2) expanded park-n-ride facilities, (3) expanded bus service, and (4) carpool/vanpool programs, including corridor-specific matching, special leased-van programs, etc.

The main problems with the HOVL on the Stevenson are the rather low bus volume, the close balance of east- and westbound traffic, and the high number of trucks traveling on the expressway. A recent analysis of the potential for a HOVL on the

Stevenson recommended a reversible contra-flow lane treatment (in-bound AM, out-bound PM),[1] but with-flow lanes are presently favored by the City's transportation planners. The median lane concept causes weaving problems for vehicles going to and from the access and egress ramps, and a "curb lane" HOVL creates conflicts between vehicles in the lane and traffic entering from right-hand ramps. The first problem could be solved with the construction of exclusive lane ramps, but the construction costs are seen as prohibitively high; the second problem can be helped by a bus-activated ramp metering system that would delay entering vehicles until buses had passed, but would thereby limit the lane to buses only. The decision to allow only buses or buses and carpools is still unresolved, but bus volume is presently too low to justify a bus-only policy. The benefits of the lane itself, backed by park-n-ride facilities and expanded bus service, could increase patronage somewhat; the present peak hour volume is only 30 buses and 1300 passengers -- well below the recommended level of 60-90 buses and 2400-3600 passengers for a with-flow expressway bus lane.[2] This minimum capacity could be met by allowing carpools on the lane as well, but CTA planners feel that buses and carpools operating together in a single-lane HOVL would minimize the transit travel time savings. This problem however, has not occurred on the Santa Monica Freeway with-flow HOVL.[3]

2) Project Costs. As no commitment has been made on the location or form of a HOVL in the Stevenson Expressway/Archer Avenue[4] corridor, no cost figures have been generated. The eventual cost would depend upon the lane's length, position on the highway, and the need for any associated construction, i.e., special HOVL ramps, ramp metering system, reconstructed shoulder lane, etc.

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[1] GCA/Technology Division, Evaluation of Transportation Control Strategies for Chicago: Final Report. Prepared for Federal EPA-Region V (April 1975).

[2] Herbert Levinson et al., Bus Use of Highways: Planning and Design Guidelines, National Cooperative Highway Research Program Report No. 155. TRB. (Washington, D.C., 1975).

[3] See discussion of this HOVL operation in the Los Angeles Case Study section of this report.

[4] As mentioned earlier, Archer Avenue is also being considered for a special signal pre-emption system. This arterial, however, is viewed as secondary to the Stevenson Expressway, in terms of potential impact on modal split due to HOVL implementation.

3) Impact on Traffic. The GCA report on the Chicago TCP foresaw a maximum reduction of roughly 2000 auto trips (1200 of which would enter the Chicago CBD) due to a HOVL on the Stevenson Expressway. This estimate was seen as rather high considering the relatively low population density of the Southwest Corridor, and was chosen more as a measure of the minimum change needed to justify a HOVL rather than a calculation of the expected increase in transit demand. A similar 2000 automobile driver maximum diversion was set for the North Lake Shore Drive, which presently carries 3400 bus passengers in the peak morning hour. The GCA, however, expressed the fear that additional surface transit ridership in that corridor would probably hurt patronage on rail lines. Even if both the Stevenson and NLSD lanes were implemented and 4000 auto drivers were diverted into buses, the reduction in vehicle trips and VMT for both the CBD and the metropolitan region would be only 2.4 percent.[1] This would assume that all drivers switched to buses for their entire trip, more used carpools, and more drove to park-n-ride lots to meet their buses.

4) Future Prospects. In summary, the number of corridors in Chicago for which HOVLs can effectively be implemented are fairly limited due mainly to the existence of one of the most extensive rail networks in the country. Only the Stevenson Expressway HOVL seems justifiable; but, even if both expressway HOVLs mentioned above were implemented, the overall impact on air quality would be minimal even under "maximum diversion" assumptions. A more exact statement of the feasibility of the Stevenson HOVL, including the optimal lane configurations and vehicles permitted, can only be made after the present study of that corridor is completed.

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[1] GCA/Technology Division (1975) p. 89.

Carpool Matching Programs

WBBM Radio Carpool Program

1) Background and Organization. In response to the impact of the energy crisis on the Chicago area, this CBS radio affiliate began a carpool matching program for the Chicago metropolitan area in January 1974. Unlike some other radio station-based matching efforts which were aimed toward the general public, WBBM's program -- "Work Together - Ride Together" -- was strictly employer-based. The program's director stated that this method was chosen because (a) commuters viewed this as "safer" since matching would be with fellow employees only, (b) all those in each group to be matched shared a common location, which increased the chances of a match over "area-to-area" systems, and (c) the intra-pool communication deemed necessary to sustain a group-riding arrangement would be easier with intra-firm groups. The program was funded and operated entirely by the station with no substantial input from government agencies.

A significant factor in the program was the method of distributing questionnaires. A station representative would make phone contact with, and then visit each firm. Forms would be included in the employees' paycheck envelopes. A comparison of the effectiveness of paycheck versus bulletin-board or other "publicly available" distribution systems used at the University of Minnesota showed that the pay envelope (registration packet for students) resulted in a much higher questionnaire return rate.[1]

Completed questionnaires were returned to the employers' personnel offices, where WBBM collected them and carried out the matching process on the station's own computer. Within one month, 175 firms had been contacted, including over 150,000 employees. One of these sites was the Elk Grove Village Industrial Park which includes around 1,400 firms and 30,000 employees. The number of questionnaires actually filled out was as disappointingly small as in similar matching efforts; only 20,000 returned completed applications (13 percent) of which about 80 percent could actually be matched. Some firms required all their employees to fill out the forms, but the majority made it a voluntary process.

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[1] K. Kozar, University of Minnesota, pp. 9-10.

2) Project Costs. The program's director estimated the following costs for the WBBM carpool matching drive:

Materials (questionnaires, other forms, envelopes, stationery, etc.)	$ 20,000
Computer time, keypunching and related data processing	30,000
Employee salaries, fringe benefits, etc.	20,000
Radio advertising and promotion	200,000
	$270,000

The staff salaries and airtime must be viewed as "opportunity costs" in that the same air time could have been sold commercially for the dollar amount listed. If the existing radio staff were not available, roughly $20,000 would have to be spent in hiring personnel. From a "marginal cost" viewpoint, no new staff members were added, and part of the air time probably would have been used for other non-profit, public service announcements. It is clear, however, that the station did make a substantial and professional effort to increase carpooling. The following section briefly outlines the reactions of a number of sample firms in the Chicago area to the WBBM program and to carpooling in general. Because the program ceased operations about two years ago and also was never a statistics-oriented operation, the amount and quality of data is low with employers' feelings often substituting for survey-type data.

3) Impact of the Program. The following response patterns and characteristics among program respondents were observed:

(1) Within the "Loop" area of downtown Chicago, the response rate among employees at 20 firms and agencies was close to zero. The program's director felt that the very high transit use in that acted against carpool formation.[1]

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[1] CTA estimate of transit's share of work-trips for the Loop area is about 86 percent versus 77 percent for combined all-trip purposes.

(2) Those firms that provided strong support to the matching effort and overall carpooling drive had noticeably higher success levels. This result confirms the significant "effort factor" found in the analysis of the carpool incentive programs in New Jersey.[1]

(3) The high percentage of strong ethnic groups within the employee population, especially Hispanic, Greeks, and Orientals tended to be detrimental to matching. Employers stated that many husbands or wives did not want their spouses riding with strangers, since a carpool was seen as a personal relationship.

(4) The fear often expressed was that the information on the employee's residential location and traveling habits would be misused either to burglarize their homes, make crank calls, or put them on "junk" mailing lists. Lower income, minority workers were most likely to express these fears.

No systematic follow-up survey was performed by the station; but, based on personal contact between the program's director and most of the employers, the waning of the energy crisis greatly decreased both the interest in the program and the desire to actually form carpools. Most of the matching applicants did not receive their carpool list until mid- to late-March when the crisis had effectively ended. Even as early as March 1st, the program's momentum had lessened particularly after President Nixon's statement that the "crisis is over." The number of new employers expressing interest was reduced to a few per week. With no follow-up survey, and empirical statement on the program's effectiveness in terms of $\frac{\text{\# of employees entering carpools}}{\text{\# of employees in target population}}$ is not possible. Based on discussions with 10 employers in April 1975, however, the overall results would seem to exceed those achieved in the WBZ/ALA program in Boston, Massachusetts. WBZ/ALA had only 13,000 completed forms out of one million distributed; and only 29 percent of these were matched. Roughly 10 percent of those matched formed pools, though this estimate is very inexact.[1] Those employers interviewed in Chicago felt that about 10 percent of those matched actually joined a carpool.

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[1] See page B-4 .

Case Examples of Firms in the Chicago Area

Elk Grove Village Industrial Park.

Location: Inner suburbs of Chicago.

Transit Service: Poor

Number of Employees: 30,000 at 1,400 firms.

Type of Program: WBBM Matching Program through firms' Chamber of Commerce; less than one percent of employees filed forms.

Date of Implementation: February 1974.

Costs: No cost to firm.

Change in Modal Split: None.

Located in a suburban area on the north-western outskirts of Chicago within a few miles of O'Hare Airport, this industrial concentration is considered the largest industrial park in the world. Actually, it is not a single entity, but a collection of "parks" and individual firms scattered in and around the town of Elk Grove. Parking for employees if free while transit service for most employees is viewed as poor or non-existant. WBBM handled Elk Grove's matching effort through the area's Chamber of Commerce and Industry which received the applications and back-up materials, and mailed them to the personnel office of the individual firms.

This lack of direct contact between the project's staff and the individual firms proved fatal to its success. Almost no filled-out questionnaires were returned. From 1,400 firms with close to 30,000 commuting employees receiving them, only 100 to 150 questionnaires were returned to the station. The Chamber's representative stated that firms made the forms available on bulletin boards and in personnel offices but did not use the pay envelope method. It was impossible for WBBM do deal more directly with such a large number of firms.

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[1] William Berry, On the Economic Incentives for Commuter Carpooling, Doctoral thesis, Harvard University, Graduate School of Business Administration (September, 1975), p. 98.

Pheoll Corporation

Location: Fringe area of Chicago

Transit Service: Good for Chicago residents; poor for suburban residents.

Number of Employees: 600

Type of Program: Internal volunteer manual matching; in-house publicity (turned down WBBM offer).

Date of Implementation: February 1974.

Costs: Virtually no cost.

Change in Mode Split: No impact, very few signed up for matching.

Pheoll is a medium-sized plant of 600 employees in the Cicero area of western Chicago, which is dominated by middle-class row-housing rather than industrial development. This employer was asked by WBBM to join the program, but declined since it already had its own manual matching system. Employees filled in cards with information on residential location and carpool preferences, such as driver, rider, women only, etc. Unfortunately, despite a reasonable amount of in-house support, the program was, in the words of the personnel office, a "complete bomb", even though 75 to 80 percent of the employees drive to work alone.

The following problems arose:

(a) Employees of different status, such as management and blue collar, showed a discomfort or strong resistance to inter-group carpooling.

(b) A flexible working-hours policy with three different morning shift times effectively divided the 450 driving commuters into three 150 groups and thereby reduced the probability of successful matching.

(c) Many employees mentioned the need for a car before or after work for shopping, entertainment, etc. making carpooling difficult.

Despite these problems, the personnel office and a number of employees were interested in the vanpool or subscription bus idea, particularly because these modes potentially could alleviate the need for a second car. The firm's amangement, however, is not very interested in the concept although it is being studied.

Sunbeam Corporation.

Location: Fringe area of Chicago.

Transit Service: Good to Chicago; poor to rest of the region.

Number of Employees: 2,400

Type of Program: Internal, volunteer manual matching (turned down WBBM offer).

Date of Implementation: February 1974.

Costs: Very low cost.

Change in Mode Split: Too few responded to do matching; about two-thirds still drive alone.

Sumbeam has a large plant on the western fringes of Chicago with around 2,400 employees. This employer had heard about the WBBM program, but was not interested in making personnel information available to an out side group or agency. At the beginning of the energy crisis in late 1973, Sunbeam established their own carpooling effort with manual matching services available to interested employees. Unfortunately, not enough employees filled out carpool cards in order to make the matching process functional. Parking at the plant is no problem. The carpool coordinator considered preferential carpool spaces, but saw them as ineffectual at that site. In recent years, the real transportation problem at Sunbeam has been in the mass transit area, especially since CTA closed the Central Avenue "El" stop near their plant. Bus service between the plant and the rest of Chicago is satisfactory, but bus access to the suburban areas where most of the employees live (no exact figure available) is poor or non-existent. Present mode split is estimated at 20-25 percent transit and the rest by car, with at least 8 out of 10 employees in the remaining 75-80 percent driving alone. The firm's representatives did not think that the more sophisticated WBBM matching program would have had more impact than their own in-house effort.

Chicago Wheel Manufacturing Company

Location: Downtown Chicago.

Transit Service: Very good.

Number of Employees: 60.

Type of Program: WBBM matching (all filed forms).

Date of Implementation: February 1974.

Cost: No costs to employer.

Change in Mode Split: None; 80 percent of employees already in 2+ passenger carpools.

The Wheel Manufacturing Company is a small firm of 60 employees within the CBD area of Chicago. This employer gave full support to the WBBM program and had all its employees fill out the questionnaires. Transit service is excellent at their location, including bus, elevated and commuter rail service. The only reason that carpooling was not increased by the program was that about 80 percent of the employees already drove to work in 2 or 3 passenger cars. Many employees came from the same neighborhoods or even the same family making the group travel both socially and physically feasible. The firm was impressed by the WBBM program, however, and felt that the extensive personal contact between the station and individual firms was crucial to the exchange of often-personal information about employees' homes and travel patterns.

Additional Carpool Programs: WIND Radio

During the height of the energy crisis, this affiliate of the Westinghouse Broadcasting System gave extensive air time in support of carpooling and offered free, computerized matching services to both the general public and individual employers who wanted intra-firm matching. In its overall approach and impact, it was much smaller than the WBBM program with about 25,000 forms distributed, but only eight firms requesting the matching services. Eventually, only 3,000 completed applications were received. In summary, this program was less successful than the WBBM project, especially in its general public matching effort

Present and Future Prospects for Carpool Services

As of April 1976, there are no public or private carpool/vanpool matching programs operating in Chicago. Thus, this is the only city of the four studied that is without such an organization. However, the results of previous efforts, especially of the WBBM program, showed that carpool matching alone has very little impact particularly when firms have no legal requirement to comply and when parallel support incentives or disincentives, such as parking or toll charges, park-n-ride "staging areas", HOVLs, etc., are not offered. The impetus resulting from the 1973-74 oil crisis as well as the consciousness-raising probably made these programs more successful than would otherwise have been possible. The severe drop in carpool interest after the long gas lines disappeared attests to this.

Park- n-Ride Lots as an Effective Strategy.

The GCA study of the Chicago area felt that a regionally implemented park- n-ride strategy had the "greatest potential for quickly reducing automobile travel in the Chicago TCA."[1] The study identified a maximum of 30,000 potential park- n-ride spaces, including excess spaces on weekdays at 21 suburban shopping centers (10,700 spaces), four race tracks (8,300 spaces), Midway Airport (1,200 spaces), and 10,000 spaces at three sports parks and stadiums. It assumes that various types of arrangements based primarily on mutual economic gain could be worked out between the appropriate owners or landlords and the City of Chicago. Their "reasonable" estimate of only 12,000 spaces seems more plausable. The assumption used by GCA that 60 percent of the spaces would be used by drivers switching to transit seems questionable in that there is no analytical basis for this figure. Some park- n-ride facilities are constantly filled while others are rarely used, and it is difficult to predetermine what will happen in each case.

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[1] GCA/Technology, p.1: TCA = transportation control area = the Central Business District of Chicago bounded by Chicago Av. (N), Halsted St. (W), Roosevelt Rd. (S), and Lake Michigan (E).

The important point, however, is that a relatively large number of spaces are available in the suburban fringe for use as carpool staging areas or for switching to rail or surface transit. The CTA rail system already has about 2,600 spaces at eight of its stations with a peak-hour utilization of over 90 percent.[1] Up to eight substantial parking garage structures have been slated for construction at rail transit stops along the Dan Ryan, Eisenhower, and Kennedy Expressways to expand the park- n-ride service for the CTA rail system. Implementation of these facilities, however, is presently delayed due to funding problems and the tremendous increase in construction costs over the original estimates. Completion of these facilities could increase transit patronage while reducing the level of vehicular travel into the CBD; considering the delay, or possible cancellation of their construction, however, more serious consideration should be given to the potential use of the low-cost and immediately available spaces at sports areas, shopping centers, and churches. The attraction of such spaces to commuters is not as strong as that of covered parking garages directly connected to rail lines, but such transit service improvements as express bus stops at these lots or mini-shuttle buses to rail stations can help attract these potential riders. The economic rationale for commuters to switch from their cars to transit even though they still must use their car for a portion of their trip, depends on the perceived difference in travel costs between (a) staying in the car for the entire trip, and (b) switching to transit at a park- n-ride lot. In a City like Chicago, where a recent survey of parkers showed that close to 92 percent parked free[1] and where a week's transit fares total $4.50, the park- n-ride option is difficult to justify for many commuters, especially with the inconvenience and "time costs" of switching modes. It must be concluded, therefore, that the prospects for a sufficiently vigorous program for park- n-ride to significantly affect oxidant levels are slight.

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[1] CTA, "CTA Rail System: Parking Near Terminals," December 17, 1975.

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[1] Peat, Marwick and Mitchell & Co., Carpool Impact Study: Technical Memorandum II - Survey Tabulations and Evaluations, Draft study prepared for Federal Energy Administration (December, 1975).

CITY IV: LOS ANGELES, CALIFORNIA

Transportation Control Plan

Even more than in other cities, the disparity in Los Angeles between the transportation system controls mandated by the official Transportation Control Plan (TCP) and the actual implementation of these strategies has been strikingly wide. The primary provisions of the Transportation Control Plan are (1) phased introduction of high-occupancy vehicle lanes (HOVL) on existing freeways to reduce single-passenger automobile use by providing preferential treatment to buses and carpools; (2) retrofiting of the existing vehicular fleet with catalysts; (3) a carpool program that would be implemented during advanced stages of a smog "alert," and (4) an inspection/maintenance program for vehicles. In practice, the region has continued to follow the transportation plan formulated by SCAG, the Southern California Association of Governments, in their Short Range Transportation Plan of April 11, 1974.

SCAG's Plan has many of the attributes of a standard Transportation Control Plan. As an objective, SCAG's Plan identifies attainment of measureable improvements in air quality within the region by 1977; and oxidants have been identified as the primary pollutant since ambient levels exceed (1974) national standards by the widest margin, 780 percent. The essential problem, the report concludes, is to raise the occupancy rate of existing vehicles, primarily by implementing (a) preferential treatment for high-occupancy vehicles on freeways and major arterials, (b) carpool action programs, (c) transit development strategies, (d) bicycle-related programs, and (e) commuter rail services. Emphasis is placed upon the first and second strategies.

HOVL Programs

General Background and Planning. In SCAG's plan, four HOVL concepts have been identified:

1) Contra-flow for buses only: Hollywood Freeway.
2) Preferential entry ramp metering for buses and carpools: Golden State Freeway.
3) Exclusive with-flow lanes on improved median shoulder for buses and carpools: San Diego and Artesia Freeway.
4) Exclusive with-flow on existing lanes for buses and carpools: Santa Monica Freeway.

The approach is to implement the concepts on an experimental basis on the selected freeways. After evaluation, the more successful technique could be extended to other freeways. In all cases except one, however, projects have been either selectively implemented or interpreted in a manner that tends to reduce or actually reverse the emission-reduction goal.

The Hollywood Freeway, for example, was selected for a contra-flow HOVL because, for historical reasons, a constriction in the roadway impeded traffic in one direction, creating a directional disparity that was unusual for the Los Angeles area where traffic in both directions is usually equally congested on freeways. However, before a bus lane could be initiated, Caltrans (California Department of Transportation) completed an improvement program that removed the constriction, allowing more intensive use of the Freeway in both directions and eliminating the rationale for a contra-flow lane.

Ramp metering appeared to have sufficient attraction to have been introduced on portions of virtually all major freeways. This method controls the rate at which vehicles can enter onto freeways, thereby improving the highway's "through-put" capacity. Instead of having the signal cycles on these ramps set for up to four minutes, with longer waiting times for ramps further from the Los Angeles CBD, the cycles were set so automobiles could enter on 30-second intervals with no disparity between "close-in" and "far-our" ramps; this timing actually encouraged long-distance use of freeways by reducing congestion and travel time, thereby improving the access to the lower-cost real estate on the urban fringe. Originally viewed as a way of reducing automobile pollution, the metering system provided incentives for longer trips. The shoulder lane HOVL's remove buses and some automobiles from the existing lanes, thus reducing congestion for vehicles in all lanes, thus helping to further encourage the developmental sprawl and long-distance, single-occupant commuting that has perpetuated the oxidant problem in the Los Angeles region. Only the Santa Monica Freeway HOVL, which reduces the highway capacity available to non-prefered vehicles, could logically lead to some reduction in VMT and hydrocarbon emissions.

San Bernardino Busway

1) Background and Operations. The construction and operation of a physically separated, permanently constructed 11-mile busway facility in the median of the Santa Monica Freeway has created a complete rapid transit system. Like the freeway median rail transit system in Chicago, it provides transit vehicles with bidirectional, exclusive right-of-way with off-line stations at which about 2,000 park-and-ride spaces are provided.

The San Bernardino or El Monte Busway was completed in stages over the 1973-75 period, with its three stations and associated parking facilities completed by the end of 1975. The largest station is located in El Monte, a suburb at the eastern end of the busway about 10 miles from the Los Angeles City limits. The stations at California State College and the L.A. County Medical Center are both within the Highland Park District of eastern Los Angeles.

2. Project Costs. Though its $57 million construction costs are much lower than the new multi-billion dollar rail lines in Atlanta, Washington, D.C. and other cities, they are significantly higher than the implementation costs associated with contra-flow or with-flow HOVLs that use existing or slightly upgraded freeway lanes.

3. Impact on Traffic. Reports compiled since the busway's inception show that the volume of automobile traffic has not changed from pre-busway levels, but transit patronage has expanded greatly. In the combined five and one-half hours of morning and evening peak periods, the number of bus passengers has increased from 1,000 before the busway to around 10,500 in March 1976.[1] Part of this increase is clearly due to increases in bus service -- the number of peak period buses has increased over 300 percent since the busway opened -- and to a fare reduction to 25 cents in April 1974, replacing a complicated and more expensive zone system which charged some riders over $1. However in September 1975, a fare increase to 50 cents on

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[1] Data provided by Southern California Rapid Transit District.

these express routes along with a 20 cent increase in the charge for park-'n-ride spaces caused a temporary dip in ridership; but the lost patrons quickly returned confirming the feeling of transit planners that express bus demand is relatively "price inelastic." [1]

Though the automobile traffic volume on the regular lanes of the San Bernardino Freeway were not directly effected by the busway, it is reasonable to assume that traffic volume would probably have been much higher without the greatly expanded use of buses in that corridor, especially since over 90 percent of the busway's passengers are making four to five days/week work-trips that would otherwise be made by car.[2] Based on survey data concerning the previous mode of busway patrons and compensating for the "leakage effect" (use of cars left at home and cars used for "park-'n-ride bus access) an estimated 5,500 "potential" cars were removed from peak period traffic, reducing daily VMT by 77,000 and gasoline consumption by 66,000 gallons.[3]

4) Future Operations. A plan to open the busway to three or four person carpools is scheduled upon expiration next year of an earliar agreement with the transit authority. This plan has solid political support and the experience of the Shirley Highway busway as a model. There is, however, intense opposition from transit operators who feel that less skilled drivers in vehicles that breakdown more frequently than buses would cause both safety and time delay problems with congestion eventually totally defeating the original purpose of the busway.[4] The rider's perception of the busway as a separate rapid transit facility was seen as cricial by SCRTD staff

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[1] Based on data from two major express bus routes on the busway; July 1975 to March 1976.

[2] Based on rider survey in Bigelow-Crain Associates, Second Year Report: San Bernardino Freeway Express Bus Evaluation, prepared for SCAG (September 1975) p.60.

[3] Bigelow-Crain Associates, p. 92-95.

[4] Based on bus driver survey in Bigelow-Crain, p. 87, and discussions with SCRTD staff members.

members, stating that the perception of convenience and time savings offered by the busway was a valuable transit inducement.

In summary, the busway can be viewed as a success in terms of increased transit use, but its impact on regional air quality has been virtually nil since the 5,500 cars estimated as remived by the busway is a very small portion of total trips. It can and should be viewed, however, as a very effective link in an overall effort to reduce vehicular travel in the Los Angeles region.

Santa Monica Freeway HOVL

1) Background and Operations. Included in the November 1973 TCP for the Los Angeles ACQR as one of several HOVLs mandated for freeways in and around Los Angeles, and later in SCAG's Short Range Transportation Plan of April 1974, the implementation of the Santa Monica bus/carpool lane was scheduled at several dates in the 1974-75 period. Cancellations caused by both practical and political complications, however, delayed its opening until March 15, 1976. The plan reserves the left-hand lane in both east and west directions for the exclusive use of buses and 3-person carpools; it only affects the 12.6-mile portion of the Santa Monica Freeway (Interstate Route 10) between the Harbor and San Diego Freeways during the 6AM-10AM and 3PM-7PM weekday rush periods.

2) Project Costs. The actual costs of implementing the lane were roughly $70,000, with an additional $800,000 evaluation grant from the Urban Mass Transportation Administration. The median dividers, road signs, and traffic controls along the Santa Monica Freeway had recently been substantially upgraded as part of an over $38 million freeway improvement program.[1]

3) Impact on Traffic. The Santa Monica Freeway has a traffic volume pattern that is typical for the Los Angeles region, with eastbound and westbound traffic during peak hours virtually equal. As the following table shows, the number of vehicles and people using the freeway changed substantially when the "Diamond Lane" was implemented; one month later, however, the number of person trips was close to the base period while the number of vehicles had been reduced:

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[1] California Department of Transportation: District 7 "A Program for Preferential Treatment" July 1974.

TABLE IV-1

Impact of Implementation of Santa Monica Diamond Lane on Vehicle and Person Trip Volumes

	6 - 10 AM				3 - 7 PM			
	Eastbound		Westbound		Eastbound		Westbound	
	Vehicles	People	Vehicles	People	Vehicles	People	Vehicles	People
Before Lane (3/5/76)	28,600	33,800	24,450	25,600	27,650	35,100	28,250	35,900
First Day (3/15/76)	20,700	26,100	17,000	21,100	23,700	30,120	21,800	27,500
(3/19/76)	23,000	30,100	N.A.	N.A.	23,750	31,240	22,600	30,000
(3/25/76)	24,700	31,700	21,200	25,600	24,400	31,550	20,200	28,000
(4/2/76)	25,100	31,900	21,400	25,782	24,950	33,550	21,100	29,500
(4/6/76)	25,600	32,850	22,000	26,700	23,950	30,850	20,900	28,400
(4/13/76)	Rained Out		Rained Out		25,200	33,750	21,000	29,725
(4/15/76)	24,350	31,400	21,550	26,450	Rained Out		Rained Out	

Source: Unpublished Data: Southern California Rapid Transit District.

As these data show, the number of persons in both directions and time periods, decreased much less than the volume of vehicular traffic. In the morning peak period, for example, the volume of person trips on the freeway on April 15, 1976 was 97.4 percent of the March 15th level, but only 86.5 percent of the vehicles were used. When the Diamond Lane alone is considered, the comparison is even more dramatic. After one month, the lane was carrying 81 percent of the "before lane" person trips, but was using only 18 percent of the vehicles. This increase is attributable to a 144 percent increase in carpools and a 186 percent increase in bus riders on the lane.[1]

Two problems created by the lane were increased waiting times at entrance ramps and a rise in the number of accidents. A study of 5 ramps showed the average waiting time increasing from 4 1/2 minutes to roughly 8 minutes in the lane's first week of operation. None of these savings had a bypass lane for carpools or buses, which therefore delayed these vehicles as well. By the end of the fourth week, however,

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[1] Source: See Table IV-1 above.

the average delay was reduced to 5.8 minutes, with delays at 3 out of 5 ramps the same or lower than the pre-lane period. Accidents, usually averaging 3 to 17 per week, increased to 60 in the first week, including 44 "fender benders" with only minor property damage. By the second week, accidents had dropped to 39 and to 21 in the fourth week. Travel times for vehicles in the non-preferential lanes did, however, increase. For a commuter traveling eastbound in the morning and westbound in the evening, total round-trip travel time over the 12.6-mile segment increased roughly 17 percent (10 percent in the morning and 24 percent in the evening).

Enforcement of the lane was limited to warnings in the first 3 days, but traffic tickets have been issued since then. The violation rate the first day was over 36 percent, but this was reduced to 10 percent after one week. Personal observation of the lane on two occasions in late April showed warning signs and general lane markings to be clear, with very visible enforcement by police cars and motorcycles. The violation and accident rate has generally been much higher in the evening than the morning.[1]

4) Future Operations. The public reaction to the Diamond Lane, especially in the first few weeks, was negative to the point of outrage. Media coverage on both the local and national level stressed the negative aspects, and a resolution was passed in the Stat Assembly that called for the Diamond Lane to be changed or terminated. In addition, the transit operating subsidy provided by the County of Los Angeles to the SCRID, which operates most of the buses that use the lane, is presently in jeopardy, with some county leaders seeing the termination of the lane as a condition for further deficit financing.[2] In late April and early May, however, the publicity has been more favorable as the actual figures have become available, but the future of the Diamond Lane is far from secure.

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[1] California Department of Transportation, "Santa Monica Freeway Diamond Lane: Initial 'After' Data for First Two Weeks" (April 1976).

[2] The lane and the buses could continue to operate without these funds, but fares would have to be raised and some service cuts might be required.

Other Scheduled HOVL's for the Los Angeles Region

In addition to the present HOVL's on the Santa Monica Freeway, the El Monte Busway, and the carpool bypass lanes on the Hollywood Freeway entrance ramps, the State's Department of Transportation ("Caltrans") is planning to test the following HOVL concepts on selected freeways in the Los Angeles area over the next two years:

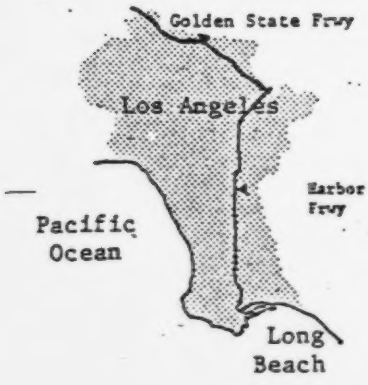
TABLE IV-2

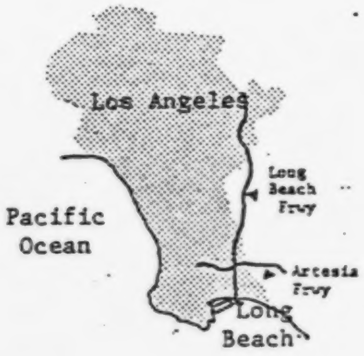
Projects, Concepts and Dates of Phase I

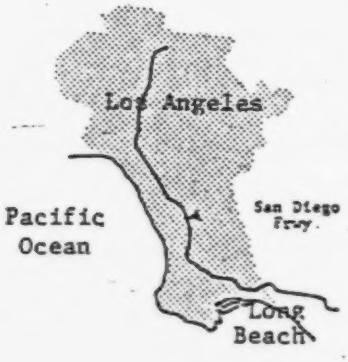
Preferential Lanes in the Los Angeles Area

Project	Concept	Opening Date
1) Santa Monica Freeway	With-Flow Carpool/Bus Lane on Existing Lane	Opened 3/15/76
2) Harbor Freeway	Preferential Ramp Bypass for Buses and Carpools	June 1976
3) Golden State Freeway	Same as 2	June 1977
4) Long Beach/Artesia Freeways	With-Flow Carpool/Bus Lane on Improved Median Shoulder Lane	January 1978
5) San Diego Freeway	Same as 4	December 1977

Source: California Dept. of Transportation. Unpublished Memo. April 1976.







Carpool Programs

Commuter Computer

1) Background and Operations. In SCAG's 1974 plan, a regional approach to carpool promotion was recommended. Carpools were to receive preferential treatment on freeways and ramp meter by-passes, and responsibility for a regional ride-sharing program was assigned to Commuter Transportation Services, Inc., with its Commuter Computer System. Commuter Transportation Services, Inc. was formed during the energy crisis of 1973-74 as a non-profit organization with the financial support of both local government agencies and private organizations and firms. Since its establishment, the purpose of the organization has been to increase regional carpooling by providing free, computerized matching services to employers as well as individual citizens. The program's initial phase concentrated on the larger (over 100 employees) firms, with smaller organizations and the general public being included later. A vanpool program was recently added in April 1976.

Between April 1974 and December 1975, over 60,000 names were placed in Commuter Computer's matching data base, with most names coming from the roughly 700 employers taking part in the program. A key element in the carpool drive has been the requirement of the Air Pollution Control District that all firms in the Los Angeles area submit a plan enabling employees to be placed into carpools on an emergency basis during advanced stages of smog alerts. Each firm has a special APCD receiver over which smog alert messages are transmitted during the 1 PM - 3 PM period preceding the alert day. Commuter Computer could, therefore, perform a dual task for the employer by (1) matching any employees who submitted completed questionnaires and requested regular carpooling, and (2) matching those who stated that they were willing to join a carpool in a smog emergency only. Unfortunately, the APCD System has never been tested, and its pollution-reducing effectiveness would be hampered by (a) the ability of employees to ride-share on such short notice, especially without frequent updating of matching lists, and (b) the fact that all employees are not required to at least request a match to pool in smog alerts.

Participation is entirely voluntary for the employees. Computer Computer's data base is presently split roughly 60/40 between regular and emergency-only matching requests.

The majority of the program's efforts has been to contact individual employees through employers at their work site. Extensive personal visits to firms have occured, including formal presentations of the program by a field representative to interested employees, hopefully on company time.

The APCD reporting forms for 34 work sites (several firms had more than one location), including (1) the number of employees requesting regular and emergency matching and (2) the present mode split of the applicants in both groups, were briefly examined to set an overview of the transportation situation at these locations. The firms were randomly selected from all areas of the 5 counties under the program's jurisdiction.

A total of 17,800 employees from these firms completed the Commuter Computer questionnaire, but only half requested regular matching. Among the firms observed, the $\frac{\text{\# questionnaires completed}}{\text{\# employees total}}$ and the portion of total requests that asked for regular matching varied widely among firms. Firm size did not stand out as a factor in this process, but since the APCD forms did not supply a total daytime employment figure, this element was difficult to measure exactly.[1]

The following mode split data were calculated for the employees of the 34 firms in the sample:

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[1] Daytime employee figures were collected by phone contact with the personnel offices of 15 firms to substantiate this factor. For other firms, total employment was used as a proxy.

TABLE IV-3

Mode Split of Employees and 34 Sample Firms in Los Angeles Area

	All Firms	Firms Within L.A. City Limits	Firms Outside L.A. City Limits
Drive Alone	69%	57%	70%
Carpool	20%	22%	20%
Mass Transit	4%	15%	3%
Motorcycle	1%	—	1%
Other	6%	6%	6%

Source: Commuter Computer, unpublished data.

The most noticeable differences between the two groups of firms are in the drive-alone and mass transit modes. For the latter mode, almost half of the suburban firms had no transit riders, while the three firms located in the CBD of Los Angeles all had transit use in the 22-30 percent range.

2) Project Costs. Commuter Computer is a 17-person operation with 14 in the main office in Los Angeles and three in the Inland Area office that handles San Bernardino and Riverside Counties. The total budget for calendar 1975 was $541,000, including $372,000 for in-house operations and $169,000 for the computer-related expenses handled within the City of Los Angeles. These figures do not include the often substantial aid provided by private industry in the assignment of a firm's personnel to assist in the matching process at its plant, in the free expertise provided by such firms as ARCO, Young and Rubicam and others, and in public service media support form radio and television stations.

3) Impact of Program. The Commuter Computer system does not include any method of measuring the extent to which their matching efforts actually lead to the formation of carpools; a very rough measure, based on very limited surveying and the results achieved elsewhere, estimates that 10-15 percent of those who receive matching lists actually join or form a carpool. This figure translates into 2400-3600 carpools formed through the program's efforts over the first two years of operation.[1] The lack of evidence to support this figure limits its use as a meaningful yardstick of effectiveness. (This is the same type of problem that most matching programs face due to the difficulty and expense of follow-up surveying.) Using the estimate of 360 carpools formed by Computer Commuter's efforts, each carpool formation has cost on the order of $600. The APCD smog alert regulations were very helpful in providing the program with access to employers who thereby received a free service that the regulation legally required them to furnish. The regulation as specified, however, can have very little impact on the everyday travel patterns of employees and the individual firm's plans for ride-sharing in a smog alert have never been tested.

An empirical statement on the ability of this program to increase carpooling is difficult to make due to the lack of follow-up data. However, based on lengthy discussions with the Commuter Computer staff and with the carpool coordinators at firms in and around Los Angeles, the following conclusions are possible:

1) The attitude and general level of effort that an employer exhibits in participating in a matching program was once again shown as a strong factor in the eventual success or failure of the carpooling drive. The firm's support must be consistant with reliable follow-through on numerous program details. Financial support is not as important as a firm's general concern and desire to increase ride-sharing among its employees.

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[1] Based on 60,000 requests for regular matching and an average carpool occupancy rate of 2.5.

2) The fears and occasional hostility asscciated with placing personal information in a data bank outside the firm have been expressed frequently as a major drawback of government-operated or sponsored programs.

3) The special characteristics of southern California with low-density commercial and residential development make carpooling difficult, especially when combined with the lack of any highway or bridge tolls and the almost universal provision of free or low-cost employee parking.

4) The jobs classification, working schedules, and methods of operation of individual firms have a significant effect on the ability to reduce employee-related VMT.

5) Location factors play less of a role in Los Angeles than in the other cities studied in theis report, since the density of development, employees-per-parking-space, existing employee mode split, and similar locational factors were fairly uniform.

4) Future Operations. The budget for 1976 is almost double 1975's level, with $664,000 for in-house operations and $285,000 for computer-related expenses, for a total of $949,000. As Table IV-2 below shows, the bulk of the funding comes from Federal Aid to Urban Systems with the 10 percent matching handled by the City of Los Angeles, the Southern California Association of Governments (SCAG) and assorted private sources.

The goal of the 1976 campaign is to roughly double the number of carpool applicants, leading to the formation of an additional 12,500 carpools.[1] In addition, Commuter Computer is presently beginning a vanpool program in cooperation with the Atlantic Richfield Company. Publicly implemented at a formal ribbon-cutting ceremony on April 26, 1976, it plans to start with a 20 van pilot project and increase the

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[1] Assumes the previously mentioned 10-15 percent formation rate.

TABLE IV - 4

FUNDING OF COMMUTER COMPUTER: 1976

"In-House" Operations			
Matching Funds (10%)			
SCAG			$60,000
Ch. of Comm., Business Assoc., Etc.			10,000
Federal Funding (Other than FAU)			25,000
FAU Funds (90%)			
Los Angeles County	63.7%		362,237
Orange County	20.6%		117,144
San Bernardino County	8.2%		46,630
Riverside County	3.7%		21,040
Ventura County	3.8%		21,609
		SUBTOTAL	$663,660
Computer Related Operations			
Matching Funds (10%)			
City of Los Angeles			28,500
FAU Funds (90%)			
City of Los Angeles			256,500
		SUBTOTAL	$285,000
		TOTAL	$984,660

Source: Director Report, Commuter Transportation Services, Inc., (November 18, 1975).

the fleet size with demand. Rather than depending on the single employer concept for vanpooling, e.g., the 3M Company, this program will attempt to form inter-company pools where necessary, drawing on the matching services already available through Commuter Computer.

Case Examples of Los Angeles Area Firms

Since no meaningful "before versus after" data were available on the change in carpooling due to the matching program or any other factors, no rigorous analysis of the factors that affect ride-sharing can be performed. The following results of brief telephone interviews with some firms that participated in the Commuter Computer plan can, however, suggest reasons for the success or failure of the carpool campaign at individual locations and for the region as a whole. This sample of ten firms, selected with the help of the Commuter Computer staff, provides a mix of industries, locations, attitudes, and program effectiveness that gives a reasonably balanced concept of the state of carpooling in the Los Angeles area.

Colwell Company, Inc.

Location: Downtown Los Angeles.

Transit Service: Good

Number of Employees: 240

Type of Program: Commuter Computer's matching program (24% requested regular matching).

Date of Implementation: Mid-1974.

Costs: No matching costs; minimal in-house publicity expenses.

Change in Mode Split: Minimal increase in carpooling above original 14%, but improved transit had increased transit share from 13% to 20$-25%.

Located on the edge of the downtown area of Los Angeles, California, this mortgage banking firm with 240 employees was very actively involved in the

Commuter Computer program. A shortage of parking spaces at their location (two-year waiting list for company spaces), with commercial parking priced at around $20 per month, increased the potential benefits that a successful carpool drive could provide. The company required all employees to fill out the questionnaires, but only 24 percent requested regular matching services, well below the 40 percent figure for the average firms. The requirement that all employees complete the forms, thereby including the 14 percent already in carpools and the 13 percent using transit, probably caused this lower carpool request rate. The firm's personnel representative stated that Colwell gave substantial in-house public relations support to the matching program, but the number of carpools formed was minimal. This lack of carpool response was attributed to the fact that (1) the parking shortage and energy crisis had already pushed carpooling to its limit, and (2) transit seemed to be more successful in siphoning off disillutioned automobile commuters than carpooling. No exact figures were available, but the combination of good, reasonably priced bus service within the city[1] and more extensive park-n-ride service for the suburban travelers had raised transit use from 13 percent to possibly 20-25 percent, especially among the clerical staff.

Farmer John, Inc.

Location: Fringe area of Los Angeles.

Transit Service: Fair to L.A. areas, poor to other locations.

Number of employees: 750 (daytime)

Type of Program: Commuter Computer's matching program (20% requested regular matching) some "carpool only" spaces.

Implementation Date: Mid-1974

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[1] There was a major bus fare reduction in Los Angeles in April 1974 with all rides costing 25 cents as compared to a complicated zone fare system with fares averaging around 45 cents.

Costs: No matching costs; minimal in-house support costs.

Change in mode split: No noticeable impact; matches generally not used.

Farmer John, Inc. is a meat packaging plant in southeast Los Angeles; this plant has around 750 day shift employees; around 28 percent completed the Commuter Computer questionnaires, of whom over 70 percent requested regular carpool matching. The plant is located near the junction of three major freeways with generally excellent access by car and ample free parking. Even though the employee population is dominated by middle to lower-middle class bule collar workers, 8 out of 10 workers drive alone to work while only 9 percent carpool and 4 percent use transit. The firm provided a nominal amount of in-house support for carpooling, but it did set up 60 "carpool only" spaces. Unfortunately, there never were enough carpools to fill these spaces, and they are presently used by all drivers. The Commuter Computer effort had almost no impact on the employee travel habits. According to the firm's representative, the two anti-carpool reasons were the fears that (1) the carpool information would be used for "junk" mailing lists or even to burglarize their homes, and (2) a carpool membership would keep the employee from taking advantage of the overtime opportunities, which many employees economically need. Transit service to the plant was considered poor for most inner-city employees' residences and effectively nonexistant for suburban residents, which accounts for the low level of transit use.

Hughes Corporation.

Location: Suburban industrial area.

Transit Service: Poor

Number of Employees: 8500 (dayshift)

Type of Program: Commuter Computer's matching program (20% requested regular matches) 500 out of 7100 spaces are "3+ person cars only"; strong in-house support, involved in subscription bus and vanpool programs.

Date of Implementation: Fall 1974

Costs: No matching costs, persistant firm support but actual costs considered low.

Change in Mode Split: Carpooling increased 20%.

The Hughes Corporation is a major employer in the Los Angeles area with over 28,00 employees at 4 locations, this firm has made significant efforts to increase ride-sharing among its employees. The location detailed here is the El Segundo plant, with roughly 8500 daytime shift employees and parking for 7100 cars. Around 7 percent of these spaces located close to the entrance have been reserved for 3-person-or-over carpools since June 1975. Over 90 percent of the employees filled out the Commuter Computer questionnaire, but of these only 22 percent requested regular matching while 35 percent wanted emergency-only matching and 43 percent were not interested in either. The firm supported what it felt was an excellent matching effort by having carpool workshops for employees, joining with the neighboring Rockwell International plant to support 7 subscription buses, and publishing a monthly "Commuter News" containing such items as "ride wanted" ads and transit routes and schedules. The firm's transportation coordinator felt that carpooling had increased roughly 20 percent as a result of the matching program and the firm's own efforts. The firm is also planning to participate strongly in Commuter Computer's vanpool program which began in April 1976.

Computax Corporation.

Location: Suburban industrial area.

Transit Service: Poor

Number of Employees: 210

Type of Program: Commuter Computer's matching program (22% requested regular matching).

Date of Implementation: Summer 1974.

Costs: No cost to firm.

Change in Mode Split: Carpooling fairly constant at 16% of work force.

Computax Corporation is a computer services firm located 1 mile from the San Diego Freeway in El Segundo, and draws most of its employees from along the coastal areas within a relatively short commuting radius of 10 miles. Of the 210 employees, almost 75 percent are programmers with the same type of unpredictable schedules that made carpooling difficult for employees at Control Data Corporation in Washington, D.C.[1] Of the 47 employees who requested regular carpool matching, only a few actually formed a carpool. There was no in-house publicity. The questionnaires were sent to supervisors with a cover letter from the firm's president stressing the voluntary nature of the program. Parking is ample, free, and convenient, bus service is poor, and the chances of pushing carpooling beyond its present 16 percent level were viewed as slight.

Huntington Memorial Hospital.

Location: Suburban town.

Transit Service: Fair to good for trips to L.A., poor to other areas.

Number of Employees: 1800 (daytime).

Type of Program: Commuter Computer's matching program (15% requested regular matching), in-house "ride-wanted" bulletin board and minimal carpool publicity.

Date of Implementation: Early 1975.

Costs: No matching costs, other efforts were inexpensive.

Change in Mode Split: No appreciable change from Commuter Computer matching, limited success through ride-sharing board.

Huntington Memorial Hospital is a large hospital with approximately 1800 daytime employees located in the northeastern suburb of Pasedena, roughly 22 percent of its daytime work force completed the questionnaire, with over 70 percent requesting regular matching services from Commuter Computer. Parking spaces are relatively plentiful, except under unusual circumstances, but local streets provide suitable back-up spaces. A recent employee survey showed that the hospital's employment pool was widely scattered, with many coming from very low-density suburbs that made the morning collection and evening distribution processes of carpooling time consuming. Though the program was given a reasonable push by the personnel office, the computerized matching seemed to have very little impact. Many did not sign up for the program to avoid "getting into another government computer," even though the secrecy of the list was explained. The personnel office felt that ride-wanted notices on bulletin boards were more effective ride-sharing tools, though typically no dependable data were available to confirm the administration's feelings about either carpool method. It was clear, however, that the many different schedules of the various hospital personnel, and the frequent overtime conditions of the nursing and para-professional staff, made ride-sharing difficult. Bus service was satisfactory between Los Angeles and the hospital but poor for suburban residents, as the 4 percent transit use figure shows.

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[1] See Washington, D.C. section of this report.

Northrup Aircraft Corporation.

Location: Suburban industrial area.

Transit Service: Poor

Number of Employees: 700

Type of Program: Commuter Computer's matching program (23% requested regular matching); shortage of spaces in firm's lot (others use street) with 10% preferential spaces.

Date of Implementation: Early 1975.

Costs: No cost for matching, and no other meaningful expenses.

Change in Mode Split: No change in relatively low carpooling rate (14% vs. 20% for average suburban firms in Commuter Computer program).

Northrup Aircraft Corporation is located adjacent to the Los Angeles International Airport at El Segundo; the aerospace firm has close to 700 employees at this office. The employee transportation coordinator termed this site a "colony location" with mostly salaried (versus hourly) personnel, one-third of whom travel frequently to the production plants in other locations of greater Los Angeles. This firm, however, has a problem that is unusual for southern California -- a severe parking space shortage. The coordinator estimates there are 150 more cars than spaces on the average day with the remainder spilling out onto the street. Since transit is poor, this shortage is a crucial morale problem. There are a small number of preferential spaces, but only 8 carpools are presently using. The firm though that the matching program might help, but no discernable change in the number of employee automobile trips has occured. The administration felt that an internal matching program with more personal follow-up and frequent updating might help. The subscription bus routes presently serving the complex of employers in El Segundo might have helped, but these buses presently carried only 4 Northrup employees.

Santa Fe Railroad.

Location: Rural area.

Transit Service: Very poor.

Number of Employees: 900 (1200 at time of matching).

Type of Program: Commuter Computer's matching program (67% requested regular matching); substantial in-house publicity.

Date of Implementation: Mid-1974.

Cost: No matching costs, other expenses minimal.

Change in Mode Split: Carpooling increased from under 10% to over 20%, but layoffs lowered it to 15%.

The Santa Fe Railroad offices are located outside San Bernardino about 50 miles east of Los Angeles, had over 1,200 employees at the time it joined the matching program. If these, almost 800 signed up for regular carpool matching lists. The firm gave strong support to the Commuter Computer staff and backed up their site visits with billboards, flyer, ads in the in-house paper, and similar efforts. Based on rough estimated compiled by the firm, the number of carpoolers was raised from 100 to roughly 250. Unfortunately, a slowdown forced the layoff of 25 percent of the work force which broke up a number of pools, but probably left carpooling at a higher level than before the matching drive. Parking is ample and free, and laid out in a way that made possible preferential carpool spaces of little merit. Once again, the dominant reason for not signing up for the matching service was the desire to stay out of another data bank and the fear that personal information in the forms would be misused. Bus service to this very spread-out work site is poor, with little hope of major improvement.

Otis Elevator Company.

Location: Rural area.

Transit Service: None

Number of Employees: 170 (260 at time of matching).

Type of Program: Commuter Computer's matching program (70% requested regular matching), already had a manual matching system since late 1973.

Date of Implementation: Summer 1974.

Costs: No cost for matching.

Change in Mode Split: Very few matches proved useful.

Otis Elevator Company, located in Cucamonga, a small town near the Ontario International Airport and about 50 miles east of Los Angeles, this firm already had implemented a manual carpool matching system before they joined the Commuter Computer program. Parking at this rural location is free and ample with no transit service to the plant. After a field representative had made a 45 minute carpool presentation on company time, almost 70 percent of the 260 employees filled out questionnaires for matching. Even with this high response rate, the matching lists were used by very few employees. The firm's personnel representative felt that the Commuter Computer effort eventually failed because (a) layoffs had reduced the work force from 260 to 170, thereby narrowing the chances for a match and breaking up some existing carpools; (b) a survey of employees showed that roughly 80 percent of the employees lived within a 12 mile radius of the plant, thus making the monetary savings from carpooling too small to compensate for the inconvenience. Many

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employees stated that using the matches provided on the printouts from Commuter Computer would require an extra 10 minutes or more in travel-time — a substantial increase when normal one-way travel-time is only 10 to 15 minutes. The firm's staff stressed that the Commuter Computer effort was excellent, but that most employees simply were not interested in carpooling.

APPENDIX D

Case Studies of Carpools, Vanpools, and HOVL Programs

APPENDIX

SECTION I

CASE STUDIES OF EMPLOYER-BASED CARPOOL PROGRAMS

The New Jersey Employee Incentive Program

Background

Because they are logical economic phenomena, carpools form frequently and spontaneously; and in only a few instances have they been studied sufficiently to amass reliable, consistent data. One of the rare exceptions is in the case of the employer incentive program required by the State of New Jersey. Under Section 1590 of New Jersey's Transportation Control Plan of June 1974, all firms or agencies with 400 or more parking spaces within a critical air-quality area (primarily in the New Jersey suburbs around New York City and Philadelphia) had to take steps to increase the use of carpools and mass transit by employees. With the cooperation of the New Jersey Department of Transportation, the Region II office of the Federal EPA has monitored and enforced the implementation of this program and made the data available for analysis.

The basic approach of the program has been to require employers to file a carpool and mass transit incentive program plan with acceptability determined by the inclusion of such elements as (a) a computerized matching system, (b) extensive intra-firm publicity, and (c) preferential carpool parking spaces. The employers have been required to submit semi-annual reports indicating changes in the mode split of employees traveling to each work site. In their initial planning step, many firms used the questionnaire-matchup method of increasing the formation of carpools. The costs of these initial matching, or later updating programs could have been paid by the Carpool Office of the New Jersey Department of Transportation, but of the firms surveyed here, all choose to organize their own matching system and cover the related expenses.

The basic approval process of the firms' plans involved (1) the submission of a plan for approval, including "base period" data on employees' mode split, number of parking spaces, estimated trips, and VMT, (2) review and approval of the plans by staff members of the Region II office of EPA, and (3) continued monitoring of the individual plans through semi-annual reports. There were numerous problems with the process of plan approval because of the difficulties in measuring the firms' actual efforts, a lack of familiarity with the locale of the employers' facilities, and the problems of obtaining cooperation from the mass transit lines, which were mostly privately owned bus companies in the local areas.

However, the program has had some success with 81 companies and State agencies having 100 parking facilities involved in the effort by December 1975, with another 34 firms scheduled to enter in early 1976. As of June 1975, the program encompassed about 174,000 employees throughout the State with over 90 percent traveling to work by car. Of the roughly 157,000 employees arriving by car and covered by the program, about 105,000 drove alone (60.3 percent) while 52,000 (30 percent) came in carpools. Between August 1973 and June 1975, carpooling reduced daily employee VMT by about 73,000 miles according to EPA estimates; and an additional drop of 175,000 miles could be attributed to a loss of 11,000 jobs at the sites included in the study. Average auto occupancy increased only 2.4 percent over this period, rising from about 1.23 to 1.26.

In this section, carpool programs implemented by 5 firms at 11 locations are analyzed. Variables include (1) the characteristics of the firm, such as location and proximity to transportation facilities; (2) the specific techniques used by the firm; and (3) the actual results achieved. By contrasting the impact of various types of programs for different locations and types of operations, factors contributing to the success of certain program elements in various locations and for specific types of employers can be identified. Because all of the firms are responding to the same legal requirement for carpooling incentives under New Jersey's Implementation Plan, and are, generally, in similar types of locations, similarities are more common than distinct differences. The 11 locations were selected to represent all major types of operations, i.e., offices, manufacturing plants, professional, etc., and locations i.e., urban, suburban, and rural. A detailed breakdown of the data received from these firms is presented in Table IA-1 at the end of this section.

Case Studies

Firm A (American Cyanamide). American Cyanamide moved its operations from Manhattan's Rockefeller Center to Passaic County in northern New Jersey during the early 1960's. A general "headquarters" type of office operation with a typical mix of salary levels among its 1,700 employees, it is now located in a rural area with a long plant (over 1,000 feet in length) positioned in the middle of a 200 acre lot. Over 90 percent of the employees are from Passaic County or the surrounding counties with an average round-trip commuting distance of about 36 miles. Instead of the usual questionnaire-computer matching method, employees were grouped by zip code using payroll information with update computer runs performed twice a year. After a publicity campaign in the intra-office Newsletter to generate support, the firm allowed employees to use the lists to locate potential carpool members either near a residence or along a travel route. A large locator map with markers for employees indicated visually the location of potential carpool members. At this location, the firm has an employee/space ratio of 1.2, a relationship conducive to carpooling. To provide incentive, a carpool sticker program with preferential parking spaces close to the plant's entrances is used. Stickers are renewed every four months as an enforcement check.

The portion of the employees traveling in carpools has been in the 31 to 34 percent range for the last 18 months. The program's administrator feels this is the maximum for carpooling without some strong disincentive against individual use of automobiles, such as another gasoline shortage or substantial increase in gasoline prices. Even with this firm's efforts, the pre-program average occupancy rate fpr employees' cars of 1.2 has not been changed.

American Cyanamide has been frustrated in efforts to bring more transit routes to the plant. A recently planned link-up between the town of Paterson, New Jersey and the plant was subverted by the dropping of the route by the operator for financial reasons. Vanpooling is also being considered, but a program has been delayed by complications with vanpool insurance. The firm is considering starting with one van purchased and insured by the employees and with the firm providing rider-matchup services.

Firm B (Bell Laboratories). Though the four locations that this employer operates throughout New Jersey are considered separate entities by US/EPA, the fact that they are all part of the same firm makes the program elements at each location roughly identical. As all locations are either in suburban or rural locations, mass transit service is generally poor. The highest percentage of employees using transit at any of the plants has been only 3.6 percent, and this percentage has since dropped to 1.6 Though New Jersey's average transit use for work trips, based on the 174,000 employees in EPA's carpool survey, is 7.6 percent, and, therefore, less than the 8.4 percent national average estimated in 1970,[1] the New Jersey figure fluctuates from 0 - 0.9 percent for 5 rural counties to 17.5 - 21 percent for the 3 most urbanized counties. Each of Bell Laboratory's four locations fits into the overall modal split pattern of its county.

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[1] U.S. DOT-FHWA, NPTS, Report No. 8, Home-to-Work Trips and Travel (August 1973), p. 8.

The basic approach used by this firm at the four locations begins with a mass transit-carpool publicity campaign and a voluntary computer matching system as the principal program elements. Employee questionnaires and the bulk of the publicity were both handled through the intra-firm newsletter, with interested employees cutting out, completing and dropping off the forms. The data collected for carpool matching was also made available for employee-chartered buses, but only one bus route was actually established between a nearby town and one of its four locations. The firm has been intensely involved with local transit agencies and Chambers of Commerce in trying to obtain changes in routes and bus-stop locations, but the generally depressed economic state of surface transit lines, further aggravated by the recent reduction in the State's transit operating subsidy and a possible strike by transit workers of the largest bus operator makes expanding the role of transit difficult. Numerous smaller efforts, such as providing bicycle racks, establishing a charter bus between various firm locations, and encouraging greater use of compact and sub-compact cars as company vehicles also were implemented by the firm, but these program elements were small in comparison to the carpooling efforts. Though the total number of employees at all locations went down by 11.6 percent, the number of carpooling employees (2 + passemgers) went up over 19 percent. From early 1974 to the end of 1975, the firm's overall "carpooling factor" $\left(\frac{\#\text{ carpoolers}}{\#\text{ employees}} \times 100\% \right)$ rose from 26 percent to 35 percent. The extensive effort of this firm to increase ride-sharing is the principle reason for such an increase even though there were employment reductions which are normally detrimental to carpooling.

One interesting observation that emerges from an interlocational comparison of the firm's four plants is that the carpooling rate was higher at locations with more available spaces per employee. However, the fact that employment dropped by 34 and 41 percent at the two locations with the lowest rates complicates any simple assumptions. Layoffs apparently tend to break up carpools and make employees more hesitant to form new ones. A solid analysis of the interrelationships among all these factors would require a more rigorous and empirical approach with a larger sample size.

The directors of Bell Laboratories' paratransit programs said that a pilot vanpool program is presently planned that hopefully would fill the voids caused by the dwindling or total lack of mass transit service in many areas. A separate vanpool questionnaire—matchup process has already been completed, routes are being formed, and driver/coordinators are being selected. Vans for the pilot program will be leased, with fares set by the firm to cover all operating costs. Efforts are being made initially to avoid operating vanpools along transit routes or the routes of the employees' subscription bus line.

Firm C (Allied Chemical Company). Allied Chemical, with about 2,500 employees at this location, is mainly an office type of organization though some technical (laboratory) work is performed on the premises. There are a few bus routes that service this location and and nearby is a commuter railroad station, but these modes have never carried more than 3 percent of the firm's employees. The firm was disparaging about the chances of greater transit use; and they noted that despite their transit promotion employee patronage of transit had steadily dropped from 3 to 0.9 percent of the employee pool in the last 18 months. They felt that the increase in carpooling was a factor in this, but no survey results existed to substantiate this theory. More apparent factors were the transit service cut-backs and fare increases that occurred over this period.

Over the past 18 months, Allied Chemical has followed its computer matching system with three complete questionnaire surveys of all employees to update its matching pool data. The most interesting aspect of this regular data collection is the change in the average trip length of single passenger cars, and the large difference between single passenger and carpool (2+ passengers) car mileage. Over a 20-month period (February 1974 to December 1975), the average round-trip VMT for single passenger cars went from 26.1 to 23.8 miles, compared to the relatively constant but much higher carpool figure of 40 miles. This substantial difference would seem to confirm the idea that commuters facing longer trips with relatively higher total travel costs would be more likely to form a pool — a hypothesis the firm's carpool administrator believed was the reason for the large disparity in VMT figures. The total figures for all 100 locations included in the New Jersey program show a similar disparity, with an average VMT of 21 miles for single passenger and almost 36 miles for carpool cars.

Allied Chemical's program had another element that was fairly common among those employers surveyed — the provision at the company's expense of expanded liability insurance for carpoolers ($1 million per accident protection) to sooth concern over possible accidents with two or more "breadwinners" in the car.

The firm's carpooling effort was one of the most successful of those surveyed, raising its carpooling rate from 34 to 41 percent and average automobile occupancy from 1.31 to 1.38. This would mean a reduction of nearly 100 vehicle trips per day for an employee pool of 2,550. While losses in both transit and "other" travel modes did counterbalance some of the gains from this program, with the number of vehicles per employee remaining constant at 0.71, a 5.5 percent reduction in annual VMT was still realized.

Firm D (International Business Machines). Similar to most of the locations surveyed, this employer's operations are in a rural area with no mass transit service. It has the typical extended building plan with numerous facilities scattered across 120 acres. The most unique factor here, however, is that the employee is more concentrated in the upper management echelons than most plants surveyed. This poses two problems for carpooling efforts: (a) the monetary savings from carpooling are less important for upper income travelers, and (b) the nature of upper management jobs is such that frequent out-of-town travel and irregular working schedules are often required, both characteristics being detrimental to carpooling. The program's director said that the dispersal pattern of the employees' residences throughout a roughly 250 square mile area made matching more difficult due to a general lack of "clusters," which also frustrated attempts to establish vanpool and subscription bus programs.

Most of the usual program elements from volunteer computer matching to intra-office publicity campaign were implemented, and the firm even joined in the production of a carpooling promotional film with the Highway Users Federation. No special efforts were made, however, to limit parking or give carpools preferential spaces with the firm's implicit "1 employee - 1 space" policy, situation aggravated by the fact that up to 20 percent of its employees travel to other work-sites on a given day.

The location's carpooling rate gradually increased in the program's first year,but it then dropped from 38 to 32 percent in the last 6 months for no apparent reason. It can be said, however, that contact with the firm's representatives at this location gave the strong impression that they considered telling employees how to travel to be improper because of both philosopical reasons and the executive nature of most of its employees. One would think that most of the carpoolers would probably come out of the office worker population, but the firm did not have any data to substantiate this feeling although the program's director thought it was probable.

Firm E (Prudential Life Insurance Company). As in the case of Bell Laboratories, this employer has four locations throughout New Jersey, each having over 400 parking spaces available. A total of about 7,700 persons are employed at the various facilities. As of December 1975, over 5,200, or two-thirds, of the firm's employees in the area were at its main headquarters in downtown Newark, where extensive surface and rail transit is readily available. About 60 percent of the employees at this CBD location used transit, but over 2,000 employees were still commuting by car.

The company owns only 409 spaces at this location, but for the last six years it has leased a total of 685 spaces in surrounding garages and lots at an annual cost of over $300,000 — much higher than parking costs at their suburban locations. The leased spaces were added to make the location more amenable to automobile commutation. Parking is provided at no cost to the employee, as is also the case at the firm's suburban facilities.

Over the past two years, this firm has had two major transportation surveys of its employees at a cost of roughly $25,000 each to (a) find out their travel patterns, (b) collect matching data for carpooling, and (c) see how people expected to travel when they were transferred from the main office to newly established suburban branches. From these surveys, a "passive" carpool file was created, and cards were filled out by employees interested in pooling. These were filed by residential location and placed in one office so employees could identify potential carpool matchups on a voluntary basis. These cards were collected at several carpool "coffee & donuts" parties where employees were seated by residential location to enable them to mingle with other interested carpoolers from this area. The firm has carried out an extensive in-house publicity campaign, offers free carpool liability insurance, and has begun to offer preferential parking spaces at its Newark location to passenger cars with occupancy rates exceeding two persons.

Of the firm's four locations studied, two increased their carpooling rates, one remained relatively unchanged and the fourth saw its rate drop. Transit usage at the Newark office decreased from 62 to 57 percent of the employee population between December 1973 and December 1975. The most important factor here, however, is the fact that over 40 percent of the employees at the main office in Newark are being switched in the first few months of 1976 to two new suburban offices. Obviously over 2000 employees at the Newark office knew for many months that they were going to be transferre to a suburban or rural environment where virtually no mass transit would be available.

Meanwhile, several of the suburban locations will have their employee population doubled within a two-month period, and another suburban office is about to be opened. Due to these rather drastic employment shifts, the firm plans to expand its vanpool program from a handfull at the end of 1975 to roughly 50 vans by mid-1976. The firm saw this move as necessary since many of the office employees in Newark had used transit and might not have a car readily available — a factor that would also help to guarantee the vanpool program's success. In effect, it was a method of keeping these employees with the firm even after a potentially disturbing change in work sites. Note that any figures from the Newark location, especially for the last six months of 1975, must be considered in the light of the anticipated employee shifts. However, the carpooling programs at the three other locations can be seen as more normal situations.

Summary Tables

Table IA-1 summarizes the changes in modal splits occupancy rate and VMT for the New Jersey firms. Table IA-2 focuses on the details of the carpool programs, such as matching method, publicity, parking controls, insurance, and promotional features, and the estimated changes in VMT, trip numbers, and gasoline consumption.

TABLE IA-1

IMPACTS OF EMPLOYER-BASED CARPOOL PROGRAMS ON VMT, #TRIPS, ENERGY CONSUMPTION

CASE-N	Firm Location	Base # of Emps.	Base Emp/ Space Ratio	Base % Transit	1/76 % Transit	% Change in Emp.	Base % Single Car Users	1/76 % Single Car Users	Base % Car-Poolers	1/76 % Car-Poolers	% Change in # of car trips	% Change in VMT per employee	% Change in Auto Occup.
1	Suburban	1100	.95	2	2	-11	73	31	25	69	-34	-34	52
2	Suburban	1609	.85	1	1	5	67	68	32	31	-1	-2	0
3	Suburban	3735	.86	0	0	-34	76	73	25	26	-2	-2	2
4	Rural	1025	.79	0	0.	-41	74	81	24	18	5	5	-4
5	Rural	4056	.84	2	2	-2	67	59	30	38	-6	-6	6
6	Suburban	3826	.69	4	2	8	70	56	25	41	-8	-8	12
7	Suburban	2467	.95	3	1	3	59	57	34	41	-0	-6	7
8	Rural	943	1.19	0	0.	7	65	68	35	32	2	2	-1
9	Urban	5254	.20	62	57	1	20	19	17	23	4	-4	8
10	Suburban	626	.72	10	5	-19	58	50	32	39	-7	-1	13
11	Rural	903	1.22	4	2.	7	72	79	24	18	6	-15	-5
12	Rural	872	.64	9	2.	10	67	72	23	24	6	-1	1
13	Suburban	7731	.84	1	1	10	79	79	20	20	2	2	-2
14	Suburban	1689	.83	6	8.	40	43	69	51	22	27	10	-23
15	Suburban	1938	.98	0	1.	10	64	59	36	40	-3	17	2
16	Suburban	1023	209	5	71	20	70	63	23	29	-7	-5	5
17	Suburban	838	.81	3	2.	9	74	66	24	33	-6	-6	7
18	Urban	1129	.53	10	10	-14	69	74	18	13	3	-36	-3
19	Urban	4090	.60	25	20	-19	44	53	30	26	12	22	-6
20	Rural	1009	1.09	1	0.	-18	43	44	56	55	3	3	-2
21	Suburban	1344	1.17	3	3	-6	69	57	28	39	-10	-14	11
22	Suburban	657	1.14	4	6	9	86	64	12	30	-12	17	11
23	Suburban	2045	.88	0	0.	-14	75	83	17	17	11	14	-9
24	Rural	797	.64	0	0	-3	31	31	63	69	0	-12.	-0
25	Suburban	1010	207	1	1.	12	81	80	18	19	1	1	-1
26	Suburban	3494	.86	10	4	2	65	72	25	21	14	20	-6
27	Rural	6672	.59	0	0	-7	40	45	60	54	6	6	-5
28	Rural	750	.96	1	1	31	56	69	43	29	12	9	-10
29	Suburban	1013	.73	0	0	-12	70	63	4	18	-3	0	4
30	Urban	1157	.67	1	1	-18	75	76	24	23	1	1	-1
31	Urban	730	1.17	2	8.	-8	59	63	14	26	14	27	-17
32	Urban	1856	.43	8	8	-10	75	75	6	6	-0	-1	0
33	Rural	502	1.01	0	0.	-7	43	71	57	29	3	28	-22
34	Rural	960	.97	0	0	-13	56	76	44	24	6	6	-6
35	Rural	625	.72	0	0.	-7	75	80	22	20	-1	-1	1
36	Suburban	1856	.75	0	0.	-16	60	78	39	22	13	-1	-11
37	Suburban	518	1.02	4	2	21	84	65	12	32	-11	-11	15
38	Suburban	1115	.61	1	1.	-8	64	72	36	25	4	49	-4
39	Urban	1358	.89	4	7.	15	48	69	18	24	42	-6	-32
40	Suburban	775	.81	10	10	-23	71	62	19	32	-6	26	6
41	Urban	1356	.93	1	2	-1	80	86	15	21	10	-4	-9
42	Urban	1401	.86	5	10	3	79	73	16	13	-11	-11	7
43	Suburban	2775	2.23	10	5	-34	75	63	15	32	-6	-64	17
44	Urban	11000	.26	27	33	-5	64	50	8	17	-17	-17	11
45	Urban	1566	.51	4	4	-9	85	65	11	10	30	-3	1
TOTAL		93195	1.29	10	10	-4	62	61	26	28	-.3	-3	+.5

TABLE IA-2 (Cont.)

LOCATION	Type of Firm & Location	Mass Transit Service Level	Average Trip Length For Empl'ee (round trip)	Program Elements for Pooling							Annual VMT (wtd.)	Annual Trips (wtd.)	Gas-oline Savings (Annual) 1/
				Matching Method	Publicity Campaign	Parking Controls	Car-pool Insurance	Special Awards Drawings, etc.	Other	Cost To Firm			
D	Administrative office, with high % of top personnel in rural setting.	None.	25 mi. (1/76)	Voluntary compter matching w/mapping board to aid process; no data on frequency of updating.	Standard in-house campaign; made car-pool movie w/H'wy Users Federation.	None All free spaces.	No.	No.	Did feasibility study of charter buses to meet transit needs; did work with local towns to boost transit; improved limousine service to airports.	N.A.	+101,250 (+2%)	400 (+2%)	-7,500
E$_1$	Central administrative offices in downtown CBD location.	Good bus, subway and commuter rail service.	16 mi. (1/76)	Survey-based invitation to carpool meetings where prospective poolers were seated by residential area, to induce car-pool formation; done annually with carpooler list available to employees.	In-house organ, pamphlets.	Parking by permit, w/new permits to pools only, no charge for spaces; carpools get preferential spaces.	Yes. No $ coverage data given.	None.	Support of transit service; working with local transit operators and gov't agencies.	Each survey costs ~$25,000, other costs not available.	-296,500 (-4.4%)	34,500 (+9%)	21,963
E$_2$	Sub-regional office, with fairly high concentration of lower skilled office workers in suburban setting.	Low.	20 mi. (1/76)	Same as E$_1$.	Same as E$_1$.	None. Spaces are free.		None.	Vanpool service starting.	See E$_1$.	-23,500 (-1.3%)	1,500 (+1.7%)	1,741
E$_3$	Sub-regional office, firm's computer center, high percentage of upper-level employees in suburban area.	Low	22 mi. (1/76)	Same as E$_1$.	Same as E$_1$.	None. Spaces are free.	Yes.	None	None	See E$_1$.	-830,500 (15%)	-27,500 (14%)	61,519
E$_4$	General office mix, mainly clerical in suburban setting.	Low.	17 mi. (1/76)	Same as E$_1$.	Same as E$_1$.	None. Spaces free at firm and other free spaces at adjacent lots.	Yes.	None.	Vanpool service starting.	See E$_1$.	-27,500 (-.7%)	30,250 (+17%)	2,037

1/ Assumes 13.5 mpg.

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T. . IA-2

COMPONENTS AND IMPACTS OF SELECTED EMPLOYER-BASED CARPOOL PROGRAMS

LOCATION	Type of Firm & Location	Base Transit Service Level	Average Trip Length For Empl'ee (round trip)	Program Elements for Pooling							Annual VMT (wtd.)	Annual Trips (wtd.)	Gas-[1] oline Savings (Annual)
				Matching Method	Publicity Campaign	Parking Controls	Carpool Insurance	Special Awards Drawings, etc.	Other	Cost To Firm			
A	General office & some labs in suburban fringe.	Minimal with recent decrease in service and fare hikes.	36 mi. (1/76)	Employees matched from payroll data by zip code; updated twice annually locator board.	Ads in house organ, bulletin boards.	Preferred parking for 2+ pools, using pool stickers; all spaces are free.	No.	No.	Worked hard to promote transit.	Sticker program cost 10% of clerk's time;other costs not available.	-209,250 (-1.6%)	-2,250 (-0.6%)	15,300
B_1	Mainly technical research labs in suburban area.	Effectively none.	23 mi. (1/76)	Employee questionnaire computer matching, annual update.	Heavy coverage in house organ.	None for carpools, all spaces are free.	No.	No.	Bus between firm's 4 locations, drop-off service to commuter RR station, encourages use of telecommunications.	None available	-243,500 (-1.9%)	-10,000 (-1.9%)	18,185
B_2	Mainly technical research labs in suburban fringe.	Minimal.	26 mi. (1/76)	Same as B_1.	Same as B_1.	Same as B_1.	No.	No.	Same as B_1.	N.A.	+160,750 (+4.9%)	+6,250 (+4.9%)	-11,907
B_3	Mainly technical research work in rural area.	Minimal.	30 mi.	Same as B_1.	Same as B_1.	Same as B_1.	No.	No.	Same as B_1 with the addition of 1 subscription bus route.	N.A.	-1,444,300	-48,300	107,000
B_4	Headquarters, main administrative offices, centralized services (data processing, payroll,etc.) plus some technical.	Some bus service, but service is being cut back and fares raised recently.	26 mi. (1/76)	Same as B1.	Same as B1.	Same as B1.	No.	No.	Worked extensively to promote transit; minor financial support to local bus, operator to set up new routes.	N.A.	-1,780,750 (-8.3%)	-69,750 (-8.3%)	131.907
C	General office operations w/ some labs in suburban fringe.	Some bus and commuter RR service; problems in arranging expanded service.	27 mi. (1/76)	Questionnaire computes match, updated annually; use house organ to aid in matching process.	Thru house organ, bulletin bds. occasional meetings.	None. All free spaces.	Yes. $1 mill. per accident.	None	Worked hard to boost use of transit, privide schedules to employees, advocate use in house organ,etc., but generally frustrated by poor service.	Each update of matching data costs roughly $100. No other cost data available.	-712,000 (5.5%)	1,500 (-0.3%)	52,720

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[1]/Assumes 13.5 mpg

Government-Sponsored Carpool Programs

General

Reports on employer-based carpools dominate the literature. This can be assumed to reflect the relatively high degree of success and political acceptability of carpool programs administered and implemented by employers. Carpool formation with other administrative bases have been discussed periodically and have been implemented in some locations. The use of public agencies to coordinate and sponsor a carpool matching program is probably the most common. The Portland Metropolitan Area Carpool Project and the Seattle-Everett SMSA Carpool Program are the examples with the most extensive available data.

Portland Metropolitan Area Carpool Project[1]

Background

Begun in the midst of the national energy crisis in January 1974, the Portland Metropolitan Area Carpool Project hoped to reduce regional gasoline consumption while helping area residents to lower their crisis-inflated commuting costs. The program's area includes 3 counties with approximately one million residents and 320,000 employed persons with most jobs located within Portland itself. Congestion problems on most major arteries entering Portland during work-related rush hours were directly related to a vehicle occupancy rate estimated to be near the national average of 1.2. With the additional acute problems of 1973 fuel crisis, the Oregon Department of Transportation applied to the Federal Highway Administration (FHWA) to use Federal Aid Urban Systems funds for a regional carpool program, as approved under Section 3 of the Emergency Highway Energy Conservation Act of 1974.[2] With this financial support, the

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[1] All information on the Portland Area Carpool Project is from Portland Metropolitan Area Carpool Project, Interim Report (December 31, 1974).

[2] This act permitted the reshuffling of federal aid, but did not increase the total amount of Urban Systems funds received. It did, however, allow for a federal/state and local funding split of 90:10 *versus* the normal 70:30 for Urban System fundds.

Tri-County Metropolitan Transportation District of Oregon (Tri-Met) implemented the Carpool Project, and personnel support was provided from both state and federal agencies.

Tri-Met's program was geared to both specific employers and the general public. Representatives of employers with over 100 employees -- over 120 firms and public agencies encompassing 53 percent of Portland's labor force -- attended workshops on carpooling goals and operations, including information on the computer matching capabilities of Tri-Met. Project personnel made follow-up visits to those employers in later months to assure that lessened effects of the energy crisis would not reduce the carpooling concept. Smaller firms and the self-employed were grouped along with the remainder of the area's population, which was also exposed to a large-scale promotional effort, using typical multi-media techniques to spur carpool development. In addition to the marketing and matching activities, Tri-Met also established park-and-ride staging areas at a number of locations, mostly churches, whose parking facilities are underutilized.

Review of First Year Results

Through the first year of the program, Tri-Met spent $214,000 of the budgeted budgeted $250,000. The breakdown of the budget, funded through a 90:10 matching agreement between FHWA and Tri-Met, is given in Table I.1. The variations between budgeted versus actual expenditures for incentive programs resulted from the legal delays in the use of churchs' tax-exempt property for the program's staging areas. Because of the delayed implementation of these areas, an accurate evaluation of their effectiveness was not possible. The combination of matching efforts, carpool promotion and non-program factors, however, were responsible for getting some 22,000 people into carpools in the Portland area, exceeding the pre-project estimates by almost 6,000 persons. Of these, private firms, mostly utilizing internally-operated matching systems, contributed almost 9,500 persons to the total while the program's own computer matching yielded roughly 1600 new carpoolers out of 8,000 requests from employees and the general public. Results from a survey of carpoolers indicate the program's general promotion campaign was the leading factor for the remaining 11,000 carpoolers who formed carpools on their own. The carpools formed by employer matching programs had an average vehicle occupancy rate of 2.49, slightly less than the 2.66 recorded for pools formed by the program's own computer matching. In addition, carpools with a CBD destination had a higher occupancy rate (2.63) than those with destinations outside the downtown area (2.44).

Most of the new carpoolers formerly travelled by automobile (through single occupancy cannot be assumed), but as many as 30 percent of the carpoolers with destinations in the CBD shifted from bus service; the figure was much lower (4 percent) for those with other destinations. On the assumption that 22,000 carpoolers would remove up to 13,170 automobiles from daily work-trip commutation (the basis for these calculations are not given), an estimate of an annual VMT reduction of almost 77 million miles and gasoline conservation of nearly 6 million gallons were calculated based on (1) an average round-trip commuting distance for carpoolers of 22.1 miles obtained from survey data, (2) 264 work days per year, and (3) a mileage figure of 12.92 miles per gallon. Utilizing this average trip distance and FWHA's 1974 eatimate of automobile operating cost of 15.9 cents per mile, including parking and tolls, total annual savings were estimated to be approximately $12.2 million, or $555 per new carpooler.

Second Year of Program

Considering the Carpool Program's results to be satisfacory, all parties agreed to fund the project for a second year through 1975. The second year's budget appears in Table IA-3. Maintaining the first year's success as well as expanding the park-and-ride facilities and employer liason program are the second year's objectives.

Commentary

There are a number of basic problems associated with these calculations.

(1) They estimated that the attraction of 22,000 people to carpooling would remove about 13,170 cars from the road. However, using data presented in various sections of the report, the authors of this review arrived at a much lower estimate, as follows:

New Carpoolers - Total = 22,000 persons

# of carpoolers who formerly traveled by car = 22,000 x weighted % of poolers (67.2%) = 14,784 persons

# cars used by these auto travelers under lowest occupancy estimate = $\frac{14784}{1.2}$ = 12,320 cars

# cars used by same travelers, but at higher occupancy rate of = $\frac{14784}{2.66}$ = 5,558 cars

Reduction in cars used due to greater carpooling by former auto travelers = 12,320 - 5558 = 6,762

# cars added to road by former transit users joining carpools = 32.8% x 22,000 = 7216 ÷ 2.66 = 2,712

NET REDUCTION IN CARS = 6267 - 2712 = 4,050

This rough estimate is less than one third the figure assumed by the program analyst, which would obviously greatly reduce the figures for reductions in VMT and gasoline consumption. In addition, no compensation was made for induced car travel by other household members who could now use the car freed by carpooling.

(2) They assumed that all cars removed from the road were standard-sized which would make friver savings over 13 percent higher than an estimate based on the average mix for standard, compact, and sub-compact cars.

(3) They assumed that the FHWA figure of 15.9 cents/mile does not include parking and toll costs. However, the FHWA figures do include a figure

of almost 2 cents/mile for "garaging, parking, tolls, etc." [1]

(4)The assumption of 264 working days per year which seems to have been used in VMT and energy reduction calculations is well above the 250-252 day work-year normally used in such calculations. This would reduce their VMT and energy savings figures by about 5 percent.

Based on these limitations, the figures presented in the report of the program's first year results as quantitative measures of its success seem to be overstated. Contact with the analysts in the Federal Highway Administration's regional office in Salem, Oregon, has generally confirmed this critique, and similar misgivings on the program's Second Year Report has delayed its release. In responding to these observations, the Director of the Portland Carpool Project stated that most firms involved in the program were located outside the downtown area with a weighted figure of 12.7 percent as the portion of carpoolers who formerly used transit, while 87.3 percent formerly drove alone. Using the same derivation presented earlier, a net reduction of 7,735 cars was calculated. This figure, based on data not provided in public reports, is a more exact estimation than the 4,050 figure shown earlier. It is, however, considerably below the original project estimate of 13,170 cars removed. No mention was made of the "leakage effect" due to the induced use of cars left at home. Even at the 7,735 carpool level and using the lower estimates of work days and mileage costs, the total savings in travel costs of well over $6 million easily justify the expense of the program.[2]

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[1] U.S. Department of Transportation/FHWA, Costs of Operating an Automobile (April 1974).

[2] Savings from reduced worktrip automobile use =
7,735 cars removed x 22.1 miles x 14¢/mile x 250 days = $5.98 million

Savings to former mass transit users =
22,000 carpoolers x 12.7% x $1.00 est. avg. daily transit expenditure x 250 = $.7 million

Total savings = $5.98 million + $.7 million = $6.68 million

TABLE IA-3

PORTLAND AREA CARPOOL PROJECT
COST SUMMARY

Expenses to December 31, 1974
(First Year)

Item	Budget	Actual Expenditures
Personnel	$ 75,400	$ 88,760
Marketing	50,000	89,302
Printing	6,000	3,447
Postage	2,000	2,532
Computer Services	8,000	3,200
Keypunching	3,000	1,178
Office & Supplies	7,000	5,370
Telephones	4,600	6,525
Travel	1,000	3,850
Data Collection	8,000	3,600
Incentive Programs	60,000	4,108
Contingencies	25,000	2,310
TOTALS	$250,000	$214,182

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TABLE IA-4

PORTLAND AREA CARPOOL PROJECT
PROPOSED BUDGET
(Second Year)

Project Coordinator/Public Information Officer	$12,120	
Employer Contact Representative	10,920	
Supplemental Park & Ride Representative	10,920	
Carpool Clerical	7,800	
Total Salaries	41,760	
Benefits & Taxes	16,704	
Total Personnel Costs		$58,464
Telephones	$ 1,800	
Postage	2,400	
Pro-rata rent, utilities, services	1,800	
Graphics and printing	6,000	
Supplies	420	
Supplemental Park & Ride Signs and installation	3,000	
Data Processing	4,800	
Automobile Expenses	2,400	
Total Non-Personnel Services Costs		$22,620
Total Proposed Budget		$81,084

FUNDING SOURCES

Carry-forward from 1974 program	$35,000
Grant from Federal Highway Administration	41,476
10% Match from Tri-Met	4,608
	$81,084.

Seattle-Everett SMSA Carpool Program

Background

In Spring 1974, a carpool program was initiated in the Seattle-Everett, Oregon Metropolitan Area, "primarily to help the area's residents cope with the existing gas shortage."[1] Though the energy crisis eased in mid-1974, the money saving potential of carpooling had been increased by higher gasoline prices. Interested in improved highway system management, the Seattle Traffic Department saw carpooling as a cost-effective method of expanding effective highway capacity. Roughly 280,000 automobile work trips occur in Seattle during the peak morning and evening rush hours (7-8 AM and 4:30-5:30 PM), and an annual traffic growth rate of 4-5 percent was projected. In addition, concerned environmental agencies pointed out that "primary health standards" for carbon monoxide were exceeded on 150 days in 1973 and 1974.

In response to these observations, the City of Seattle organized Commuter Pool, a one-year pilot project (later extended to a second year) to:

1) Organize the necessary administrative support and develop a geocoded matching system for travel origins and destinations.

2) Make marketing contact with individual employers (447 firms eventually contacted).

3) Organize and implement marketing and promotional efforts.

4) Conduct Employment Center surveys of major employment centers within the Seattle area to determine most effective transit/paratransit system approach.

5) Evaluate and assess the program's results at the end of the year.

Program Adjustments

One early conclusion during the program's first year was that without some strong exogenous influence like an energy crisis, substantial fuel or parking cost increases, or outright government regulation of automobile travel, carpool matching on a region-wide basis would not work. Having acknowledged this reality, Commuter Pool made the decision to limit efforts to three major employment areas with over 50,000 employees. Two other major employment nodes were identified for future program stages. For other areas where employment concentrations were relatively low, a regional geocoded system within the program's own operation would continue to be maintained, but the administrators felt that matching efforts would not be successful in those areas.

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[1] Data and program descriptions were drawn from City of Seattle Department of Traffic, "Commuter Pool: First Year Review and Second Year Program Elements" (August 1975).

To determine the proper approach for increasing employee use of transit and certain paratransit options, the 50,000 employees at the three selected target locations were questioned in an overall transportation survey. The goal of this survey was to outline the employees' travel patterns, needs, and modal preferences, and their willingness to carpool, ride express buses from suburban park-and-ride lots, form vanpools, and engage in other options for reducing vehicle use. For example, at the Forest Hill Hospital Complex in a congested neighborhood adjacent to the Seattle CBD, the following numbers of employees said they were "very interested" in certain paratransit and transit options:

	Total Number	Percent of Total Employee Respondents
Interested in Carpool Matching List	921	20%
Interested in Direct Shuttle Bus w/ Park-and-ride Lots	874	19%
Interested in Home-to-Work Service (Vanpool, Taxipool, etc.)	1727	37%

Source: Charles Barb, Jr., and William Roach, "Information Support Development for Paratransit Planning for Major Urban Activity Centers." Paper presented at 55th Annual Meeting of the Transportation Research Board (Washington,D.C., January, 1976).

The survey shows a clear interest in "purchased" transportation, especially the possibility of door-to-door paratransit service as compared to the carpool alternative that requires each member to have a car available for use on one or two days a week (for a typical rotating carpool). At the time of the survey, 23 percent of the respondents rode in carpools. The Seattle Planning Department strongly supported transit and paratransit efforts as a means of maintaining the residential nature of the area around the hospital which was tending to become a parking lot for hospital employees and visitors. (Over 1,000 employees surveyed said they parked in the street.) Sixty-eight percent of the employees said they had available bus service to the hospital, but only 17 percent of the employees used it. The survey suggested that if bus routes could pick up employees near their homes and provide more direct service to downtown Seattle, the system would probably attract new riders.

The cost of surveying the 7,000 employees in this hospital complex was roughly $15,000 or $2.10 per employee -- a cost that could easily be made up if only 10 percent of the 3,500 "drive alone" employees switched to transit or carpools. The hospital administrators also hope to decrease the need to expand expensive off-street parking facilities that are essential for patients and could be freed if fewer employees drove to work.

To provide additional incentives for anyone wishing to carpool into the Seattle CBD, the Carpool Project implemented a "Pool It" lot of 179 spaces in downtown Seattle; this facility is freely utilized with an average occupancy rate of 3.7 persons per car. Another downtown lot of 100 spaces is planned. The METRO Transit staff and the State Highway Department have also inventoried existing underutilized lots in suburban areas (shopping centers, church lots, etc.), and are planning on using 15 of these lots as park/ride/pool lots.

Review of First Year Results

Based on a thorough review of the Seattle-Everett Carpool Project done in 1975,[1] the following statements were made about the success of the program's first year of operation when compared with its original "target" goals.

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[1] This critique of the Seattle program is based on figures and analyses presented in TDA, Inc., "Evaluation of Seattle-Everett SMSA Car Pooling Program," Executive Summary (May 1975).

1) Program Cost and Carpool Matching Targets. The planned expenditure level of $300,000 was reached. Of the 120,000 people to be organized into carpools which would remove up to 52,000 cars from the streets during rush hour periods, only 7000 applied for carpooling with an estimated 2000 cars removed. (No basis for calculating the latter figure was given).

2) Persuade Private Employers to Provide Pooling Incentives. No meaningful incentives were provided by private industry during the first year.

3) Create Park-and-Ride Lots and Establish Exclusive Lanes. One lot has been opened, but no new ones have been added as of August 1975. No high occupancy vehicle lanes were instituted during this period.

4) Increase average automobile occupancy. No perceptible increase was measured during the program's first year.

In summing up their review of the Project, TDA's authors said that ".... the Carpool Program's areawide performance would indicate that we were open for business but the customers didn't come." However, the nature and scope of the program's first year were so broad that spectacular achievements were not realistic to expect, but the exercise seems to have been a valuable learning experience from which significant program adjustments were made. The program was initiated and run in the 1974-75 period by the Seattle Traffic Department. The second year efforts and those in following years, however, were to be organized on a broad-based, inter-governmental and inter-agency approach. The following table shows the principal agencies to be involved and the functions that each expects to perform:

Agency	Coordinating Element
Metro	Marketing, service planning, Park 'n Ride
Washington State Hwy. Dept.	Time/cost/convenience incentives development
King County	Incentives development
Puget Sound Council of Gov.	Incentives planning and development
City of Seattle	Incentives development and central management

In addition, a May 1976 meeting of policy analysts and agency representatives from the City of Seattle, METRO, King County, and Washington State Highway Department is scheduled for coordination of activities and determination of the agency or agencies that will handle such specific program elements as parking management, flexible work hour programs, preferential highway treatment, and subscription bus operations. The second year's total expenses and the sources of funds used to meet them are outlined in the following table.

Estimated Cost of Project

DIRECT LABOR	Man/Hours	Rate	Total	
Associate Transportation Planner/Manager	1920	$8.93	$17,146	
Assistant Transportation Planner/Developer	1920	6.77	12,998	
Program Assistant	1920	5.79	11,117	
Intermediate Clerk	1920	4.24	8,140	
Clerk Typist II	1920	3.83	7,354	
	9600		$56,755	
EMPLOYEE BENEFITS				
Payroll additives and fringe benefits (43% of direct labor)			$24,405	
OVERHEAD				
(32% of direct labor) Rent, telephone, office supplies, equipment, duplication		$18,162		
City Audit Costs		200		
			$18,362	
				$99,522
DIRECT COSTS				
Data Processing (Geocoding, matching and survey support) University of Washington - Urban Data Center				
·Coordination and programing support 500 hrs. @ $17/hr.		$ 8,500		
·Geocode Maintenance 520 hrs @ $12/hr.		6,240		
·Computer time				
IBM 370 - 36 hrs. @ $168/hr. (matching service)		6,048		
IBM 1130 @ 150/mo. (survey processing)		1,800		
·Miscellaneous Costs (contingencies, maps, supplies, transportation)		1,412		
			$24,000	
Employer Marketing/Educational Support				
·Development/Employer Contact 1500 hrs. @ $8/hr		$12,000		
·Marketing materials		25,500		
			$37,500	
Incentive Development				
·Preferential Access - planning, specifications, and estimates (SED & WSHD)		$20,000		
·Rental 100 Pool-It Parking Spaces		18,000		
·Vanpool loss guarantee (5 vans)		10,000		
			$48,000	
Miscellaneous Direct Expenses (not covered by overhead) Travel, postage, answering service, contract services			$ 3,500	
Contingencies (temporary personnel, match for work-study student, and unexpected demand for match service)			$ 7,978	
				$120,978
GRAND TOTAL				$220,500

Estimated Cost of Project

FEDERAL AID URBAN FUNDS		
Seattle	$101,250	
King County	60,750	
Suburban Cities	40,500	
King County Region FAUSF allocation		$202,500
LOCAL MATCH FEDERAL URBAN AID FUNDS		
City of Seattle Local General Fund		22,500
TOTAL FEDERAL AID PORTION OF PROGRAM		$225,000
SUMMARY		
Local Agency Total Federal Aid Costs		220,500
State Engineering Costs		3,000
State Audit Costs		1,500
Total Cost Estimate		225,000
Federal Share For Eligible Costs		202,500
Local Agency Share		22,500

Summary

The Seattle-Everett program is notable for (1) its response to the shortcomings of its first year approach and (2) its quick implementation of substantial adjustments in the program's focus. To analyze the project's overall success at this time is premature since the revised approach was only recently implemented. The important point, however, was that the administrators saw (a) a regionwide, centralized geocoding approach to matching was not a successful method of increasing carpools and (b) concentrated efforts at high-density employment centers are more likely to succeed. The cost of surveying employees at these locations appear reasonable when possibilities for meaningful employee and employer savings are considered. The impact of the program's $525,000 cost over the 1974-76 period has yet to be determined; but with the annual commutation costs to drivers of automobiles into Seattle amounting to over $350 million, even a one percent reduction would more than justify the project's expense. The program's analyst calculated that with total annual costs in 1975-76 of around $343,000, the formation of less than 2600 carpools would still remove 3,600 cars from the road at an annual travel cost savings of over $4 million and a benefit/cost ratio of 12 to 1.[1]

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[1] Costs include (a) program costs of $225,000 and annualized capital, maintenance and depreciation costs of 6 proposed preferential ramps of $118,000.

TABLE IA-5

COMPONENTS AND IMPACTS OF REGIONAL CARPOOL PROGRAMS

Programs Location Population	Coordinating Agency Start-Up Date	Level of Funding & Funding Sources	Major Program Elements	Target Population	# New Carpools Formed Reduction: VMT Daily Trips	Change in: -Annual Trips -VMT -Energy Consumption	Additional Information
PORTLAND METROPOLITAN AREA CARPOOL PROJECT Portland, Ore. Portland metro. area Pop: 931,200 (1975 est.)	Tri-County Metropolitan Transportation Dist. (Tri-Met) March 1974	1st yr:$214,000 2nd yr:$ 81,000 Transfer of Fed'. Aid Urban Sys Funds (FWHA) to carpooling, with 90% fed. 10% state, local split	a. Multi-media promotional effort. b. Carpool workshops with 120 major employers on carpool benefits, available matching services with follow-up visits. c. Carpool staging areas in suburban zone for smaller firms and individuals.	Journey-to-work travelers, esp. the users of 49,000 auto work trips daily into Portland (av.occ. 1.35)	8,270 carpools w/22,000 people 13,000 fewer trips 288,000 less VMT Authors' analysis of data estimated a 4,050 reduction in trips and 90,000 drop in VMT	Trips: -3.25 mil VMT: -72 mil. Gas: -5.3 mil. gal. Trips: -1.01 mil. VMT: -22.5 mil. Gas: -1.7 mil. gal.	Difficult to distinguish carpool program efforts from energy crisis or other factors Banfield Hway HOV lane opened 12/75 Av. round-trip commuting distance: carpoolers: 22.13 mi. drive alone: 17.17 mi. other modes: 14.70 mi.
SEATTLE-EVERETT SMSA CARPOOL PROJECT Seattle, Wash. SMSA Pop: 1,422,000 (1970)	City of Seattle Depts. of Engineering & Traffic (2nd yr, effort coord. with transit agencies, State H'way Dept., Puget Sound Council of Govts) March 1974	1st yr:$300,000 2nd yr:$220,500 Fed., State/Local split same as Portland	1st yr: developed geocoded regional matching system; contacted firms; conducted employment surveys at several major employment concentrations. 2nd yr: Expanded HOV lane treatments; concentrated on large employer matching and marketing efforts; increased park-&-ride and CBD carpool lots; supported all paratransit options (vanpool, carpool, subscription bus, taxi-pool etc.); flexible work-hour program.	280,000 auto work-trips in Seattle area during 7-8AM & 4:30-5:30PM (projected to increase 4%-5% annually) 1st yr: emphasized employers throughout area. 2nd yr: concentrated on 5 major employment centers.	7,000 applicants estimated to reduce trips by 2,000 daily and VMT by 46,000 (bases for calculations given; data on # carpools or auto occupancy were not provided)	Trips: -500,000 VMT: -11.5 mil. Gas: -850,000 gal.	Focus shifted from areawide matching to concentration on 5 large centers.

Summary and Conclusion

General Program Results

The carpool programs and approaches analyzed in this report tend to focus upon one common problem -- the excessive use of low-occupancy automobiles for the journey-to-work trip. As the analysts of the Seattle program pointed out, the desire to spend millions of dollars in transit expansion should be tempered by the fact that, in one rush hour, roughly 1.4 million "seats" in private automobiles are available to take travelers into the city from almost every outlying area, and less than 25 percent of the seats are taken.[1] Though programs in a number of cities have tried to "match" people from different firms but the same residential area into carpools, these efforts have been consistently frustrated by a general unwillingness of people to join with "strangers" outside their own firm, even though they may be part of a 10,000 person work force at that job location.

Although results of programs at the firms in suburban New Jersey are difficult to differentiate due to their similarity, including plant locations, parking availability, and poor transit service, a number of factors stand out: (1) firms with higher parking space/employee ratios tend to have a higher percentage of "drive alone" employees; (2) programs with consistent "follow-through" on updating of matching surveys, renewing carpool parking stickers, and continuous intra-firm publicity have generally better carpooling records; (3) the costs of the typical program are rather small due to the use of existing staff and data processing facilities at firms of this size and (4) firms that had a significant decrease in labor force over a relatively short period of time saw their carpooling rates decrease.

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[1] Assuming an average of 5 seats/car and an occupancy rate for work trips of 1.2.

Role of Government Agencies in Carpooling

Though each of the New Jersey employment locations analyzed in this report could have used the free matching and promotion services available from the New Jersey Carpool Office of the New Jersey Department of Transportation (NJ/DOT), none of them did. Many of the firms had started their programs before the State assistance became available. They, therefore, ignored the aid although they could have used it for updating their surveys. In general, firms seem to resist the intrusion of an "outsider", preferring to feel that they are voluntarily contributing to energy and environmental conservation rather than being pressured by government agencies. Complete dependence on a regional rather than employer-based type of matching program was a major cause in the relative failure of the regionwide concept used in Seattle and Portland. This followed the disappointing results of a similar approach in Boston in which 3,800 people were matched from over a million distributed questionnaires.[1] The change in approach between the Seattle program's first and second years showed that the regional matching process could still serve a purpose in lower density employment areas, but major employment concentrations were needed to make a matching process work; (a) the number of "matching"variables" needed for successful carpool formation is reduced with intra-firm programs since employees share common work schedules and destination points, and (b) employees feel more comfortable sharing travel information with fellow-workers.

Policy Implications

The most important policy implication arising from the analyses performed in this report is that the economics of carpooling are so favorable to all parties involved that they can be self-sustaining. Thus, the government's main role is educational with financial support available for firms who wish to implement programs. The "on-highway" improvements and subsidies (exclusive lanes, reduced carpool tolls) are also factors. Close attention should be given to the interrelationships between mass transit and paratransit modes, since a switch from transit to carpools has occurred in many of the programs observed. An effort can be made to use each mode in its optimal setting. For example, the Tennessee Valley Authority's Commuter Ride-Sharing program at its headquarters in Knoxville decreased "single passenger" car use among the employees from 65 percent to 19 percent between November 1973 and January 1976, while increasing carpooling from 30 percent to 43 percent, vanpooling from 0 to 7 percent, and bus ridership from 3.5 percent to 31 percent.1/

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[1] Carla Heaton, "Evaluation of an Areawide Carpooling Program: WBZ/ALA Commuter Computer Campaign (Boston, Massachusetts)", U.S./DOT Transportation Systems Center (December 1975).

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[1] S. Stokey, F. Wegmann, A. Chatterjee, "An Employer-Based Commuter Ride-Share Program in a Medium Size Urban Area," joint paper of TVA and University of Tennessee (February 1976).

APPENDIX

SECTION II

CASE STUDIES OF EMPLOYER-BASED VANPOOL PROGRAMS

Introduction

Background

As firms and their employees became interested in reducing the vehicular travel and the costs associated with daily commutation, they faced three basic modal options: (a) the private automobile, (b) surface or fixed-guideway transit, and (c) dual mode travel (e.g., car plus express bus). The theoretically optimal mode in terms of energy, the environment, and total travel cost was mass transit, but large numbers of riders located at a relatively small number of high-density residential nodes were needed to make this option practical. These conditions did not exist for firms located in rural and suburban areas, and even rudimentary transit service was rarely available. Carpooling was a possibility, but its popularity seemed rather limited. Cost savings were meager since the typical "rotating" carpool required all pool members to own a car that would be available every second or third working day.

A partial solution to this dilemma for a number of firms across the country has been the organization of vanpool services. Simply defined, a commuter van service is "a prearranged, ride-sharing form of transportation in which vans are utilized for regular tripmaking between the home and workplace."[1] The main differences between vanpools and carpools are (a) the vehicle itself (7-15 passenger van compared to 4-6 passenger cars), and (b) the operational and financial arrangements of vanpool programs compared to carpools. All publicized commuter vanpool programs are employed-based, and they usually use residential location and related travel information from employee surveys or payroll office records to match riders into pools. The significant difference is in the method of operations. A formalized commuter van service normally has (1) the purchase or leasing of the vans and arrangement of insurance, registration and related administrative matters handled by the employer, (2) fares based on round-trip distance which cover most or all of the van's capital and operating costs, and (3) a driver/coordinator who handles the driving, fare collection and other matters. The driver/coordinator is usually renumerated by not paying a fare, receiving evening and weekend use of the van, being permitted to keep all fares over a certain number, or other rewards. The first operation to receive intensive publicity was organized by the 3M Company at its Minneapolis plant in 1973; by the end of 1975, about 30 companies using over 250 vans, had adopted the concept.[1]

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[1] G. Miller and M. Green, An Analysis of Commuter Van Experience, The Urban Institute, Washington, D.C. (1976), p. 1.

Program Outlines

As case examples, four company-based commuter vanpool programs have been selected from a number of different geographical settings ranging from downtown CBD location to a semi-rural plant with contrasting methods of organization, operation, and size. A summary table of the relevant components and effects of these four programs appears at the end of the descriptions.

Case Examples

Hoffmann-LaRoche, Inc.[2]

Located in the suburban New Jersey town of Nutley, New Jersey, Hoffmann-LaRoche,Inc. was required under Section 1590 of New Jersey's Transportation Control Plan to establish an "Employer Incentive Program" to reduce automobile use through greater use of mass transit and carpools by its employees. In response to both this requirement and independent concerns of the firm with environmental degradation, traffic congestion, and energy consumption, the firm organized both a carpool matching program and a vanpool service in February 1974. At that time, around 90 percent of the workforce drove alone, while only 7 percent rode in carpools, with an average vehicle occupancy of 1.15. The location is served by several bus routes, and company officials had strongly supported its use through publicity campaigns and special lotteries. However, employees considered the service quality to be poor, and less than 3 percent were using it in early 1974. Vanpool service was viewed as a way of filling the transit void.

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[1] Miller and Green, p. 1. For a listing of current vanpool programs, see Forstater, Ira, and Ed Twomey, "Vanpooling: A Summary and Description of Existing Vanpool Programs," U.S. Environmental Protection Agency, Washington, D.C. (January, 1976).

[2] Information on Hoffmann-LaRoche program from Forstater and Twomey, p. 36; and conversations with Program Director, Robert Wald, in February, 1976.

After a survey (a joint carpool/vanpool questionnaire) that concentrated on employees commuting distances of at least 7-10 miles or more one-way, a cooperative, interdepartmental effort was made to gain the legal, administrative and related expertise needed to design a commuter vanpool program. Interested employees were matched into prospective pools, and drivers were selected for each. Vans were leased from a local firm rather than make the commitment of vehicle purchase. Though the program has been rather successful in its almost two years of operation, the firm has yet to exercise its option to buy the vans. The drivers collect fares and arrange for service at the firm's own maintenance facilities with these costs included in the fare base. As compensation, the driver is not required to pay a fare but does not receive any additional monetary rewards and must pay 7 cents per mile for any evening or weekend use of the van.

The costs of leasing, maintenance, insurance, vehicle licensing, and basic operating costs are covered by fares, but the firm's administrative costs are not included in this base. The vans' range of service extends from 20 to 120 miles round trip, with an average round trip length of roughly 55 miles and a monthly fare of $26.47. Fares are based on an 11 passenger split, and the firm subsidizes vans if occupancy falls below this level. Vans that drop to 8 passengers have one month to increase their occupancy before that route is dissolved; but, with waiting lists for all routes, this has not been a problem.

The success of the program has made worries about underutilized vans unnecessary. Service has expanded from 4 vans with 41 passengers in April 1974, to 20 vans carrying 240 employees in 1976. This occurred at the same time that transit use and carpooling among employees were also increasing. Between April 1974 and July 1975, the number of employees at the plant rose by 2.5 percent, but employees using transit and carpools increased by 14 and 27 percent, respectively.

Information about the cost of the vanpool program's administration and promotion was difficult to separate from the annual figure of $4000 for the overall carpool/vanpool/mass transit effort. An additional 13 percent of two employees' time is allotted to the program (no salary figures were given). The firm's administrators stressed that no federal, state, or local assistance was used to support any of their transit or paratransit programs.

Vanpool riders were believed to come more from the office than the production personnel, because of the 9-to-5 nature of office work compared to the multiple shifts of the manufacturing processes. Administrators also assumed that almost all of the vanpool riders formerly drove alone to work -- an assumption based on the steady decrease (down 5.5 percent from April 1974 to June 1975) in the portion of employees in single passenger cars at the plant during the program's history. This assumption has not been substantiated by a follow-up survey of vanpooling employees.

At an average roundtrip distance for vanpoolers of 55 miles, 240 former "drive alone" poolers over 250 work days would have the following VMT savings:

240 cars x 55 miles x 250 days = 3,300,000 VMT
20 vans x 55 miles x 250 days = 275,000 VMT
Total VMT Savings= 3,025,000/year

A more reasonable assumption would be to use the average automobile occupancy rate when the program began of 1.15, which would mean that $\frac{240 \text{ passengers}}{1.15} \simeq 209$ cars were removed by the use of vanpools, which would result in a VMT drop of 2.6 million a year.

Energy savings from this drop in car use would be:

$$\text{Before -- } \frac{3{,}020{,}000}{13.5 \text{ mpg } \underline{1}/} \text{ car VMT} = 223{,}703 \text{ gallons}$$

$$\text{After -- } \frac{275{,}000}{12 \text{ mpg } \underline{1}/} \text{ van VMT} = \underline{22{,}917 \text{ gallons}}$$

$$\text{Total Annual Savings} = 200{,}786 \text{ gallons}$$

1/ 13.5 mpg car figure based on FHWA analyses is a rough approximation utilized to show order-of-magnitude energy savings. The van figure of 12 mpg is the result achieved in the 3M Vanpool Program, which is assumed to apply here.

This also assumes that none of the vanpoolers were former transit users or were dropped off by employees from another firm. It does seem justifiable, however, to label the vanpool program and the company's overall drive to increase transit and carpool use as reasonably successful.

3M Company[1]

The commuter vanpool program at the 3M plant in suburban St. Paul, Minnesota has been widely publicized in the last two years as the first major employer-based vanpool program, and, possibly, the most successful. The facility, which is located on a 400 acre "campus," is the firm's main headquarters with the associated concentration of office-type operations; but it also has extensive laboratory facilities. The firm employs close to 10,000 people in the complex, up from 7700 in 1970. The site has convenient access to highways, but transit service is poor. Two "subscription bus" routes have helped slightly, but these carry less than 1 percent of the employees. 3M realized in the early 1970's that their employee population would expand drastically by 1980, the growth in traffic congestion at the plant site would have to be controlled, and steps would have to be taken to limit the need for new employee parking facilities. Carpooling efforts were tried, but these were not considered successful.

3M began a 6-vehicle commuter van pilot project in April 1973. Within 2 1/2 years, this had expanded to 75 vans carrying 830 passengers daily. The firm surveyed employee interest, organized employee meetings and other promotional efforts, selected the vanpool routes, "driver/coordinators," purchased the vehicles, and handled licenses and related administrative details. The drivers have had responsibility for the selection of passengers and routes, but they are limited to a reasonably sized pickup area. They must pick up each passenger at his or her residence or at some other prearranged meeting place. Before initiating the service, the coordinator has to arrange a "pool formation meeting" with the passengers at which the fare structure, routes, schedules, and other details are announced. Monthly fare payments are to be made to the company cashier, although the driver is in charge of distributing monthly bills. In compensation for these services, the driver does not pay a fare, keeps any fares collected from a ninth, tenth or eleventh passenger, and has the use of the van during evenings and on weekends, but a payment of 8 cents/mile must be made for this personal use.

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[1] Information on 3M program obtained from Forstater and Twomey, pp. 58-59; Owens, Robert and Helen Sever, The 3M Commute-a-Van Program Status Report, 3M Company, St. Paul, Minnesota (May 1974); and conversations with Owens and Severs in February 1976.

Vanpools are provided free preferential spaces in enclosed parking ramps that are closer to most job sites, and which cost regular cars $15 per month. Most of the van's maintenance work is performed by 3M's own mechanics with only 20 percent sent to local service stations. These costs are included in the fare base along with the costs of vehicle depreciation, gasoline, oil, tires, insurance, and related operating expenses. Fares are split 8 ways (e.g., each passenger pays 1/8 of the van's alloted costs). The program now promotes itself but requires two full-time program personnel and 25 percent of a traffic engineer's time. The firm also has 3 back-up vans in case one of the regular vans breaks down, and these vehicles are used for mail delivery among 3M's 17 buildings.

Fares are based on route distance with the per mile charge decreasing as route mileage increass; monthly fares range from $16.25 for a 5 mile trip to $43.36 for a 150 mile round trip with an average distance and fare of around 50 miles and $27. The firm will subsidize routes that fall below 8 passengers, while helping the driver secure new passengers, mainly through a computerized list of employees coded by residential location, and intra-firm advertising of the openings.

The program has been very successful, and it is presently the largest employer-based vanpool service in the country. The company has received considerable favorable local and national publicity and was also able to postpone the construction of additional parking spaces. The 7700 employees in 1970 and 6200 spaces at an employee parking space ratio of 1.24. By increasing that ratio to 1.55 by 1974 as employment increased to 9500, the number of spaces needed was only $\frac{9500}{1.55} = 6130$ compared to $\frac{9500}{1.24} = 7660$ spaces at the pervious mode split, a savings of over 1500 spaces. 3M estimates that this reduction saved over $3 million in parking space construction costs.

3M estimated that the average van, with 11.1 passengers, reduced employee car travel to the plant by 6.5 cars. At the February 1976 level of 75 vans, this means 488 cars were removed. The VMT reduction estimate using a 14.4 mile average trip distance figure based on a survey of all 3M employees, would be 488 cars x 250 work days x 14.4 miles = 1.76 million miles VMT reduction and a gasoline savings of 1,760,000/15 mpg = 117,333 gallons of gasoline.[1] The program's analysts did not subtract the van's VMT from these savings.

The 3M program administrators had the following survey information on the former modes of vanpool users:

Drive alone	49%
Drive w/passengers	7%
Rotating carpool driver	23%
Carpool rider	16%
Other	5%

From this information, it appears that 56 percent of the vanpool riders formerly drove a car, which would mean a minimum of 6.2 cars removed at 11.1 passengers per van. Rotating drivers drove their car 1 to 3 times a week, so on any given day an additional 5 percent to 14 percent of these persons would have driven a car, raising the 56 percent figure to a 61 to 70 percent range. However, the vanpool survey also showed that only 70 percent used the van service 5 days a week, 25 percent used it 4 days and 5 percent used it 1 to 3 days, which means a weighted average of 765 persons or 92 percent of the total vanpool population actually use the vans on a given day. Using the range of employees driving cars calculated above, this means that 467 to 536 cars would be removed, or a range of 6.2 to 7.1 cars per van. The 6.5 cars per van figure used by the 3M Comapny would therefore seem to be a reasonable estimate, assuming that the carpools impacted by the defection to vanpools did not result in the break up of carpools. For example, unless the passengers who traveled with the 7 percent "drive w/passenger" group also switched to vanpools, they would have to use cars, which would lower the VMT savings somewhat. 3M, however, has no post-program employee mode split information to confirm this hypothesis.

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[1] The 15 mpg figure for automobiles was utilized by 3M project officials. No derivation or source for this figure was given.

It would seem justifiable to use the average trip distance of vanpoolers (50 miles) instead of the 14.4 mile figure for all employees to estimate vanpool-related VMT reductions. When the vans' VMT figure is included in these calculations, a reasonable estimate of the vanpool program's VMT impact would be:

66.5 cars removed/van x 75 vans x 50 miles x 250 days = 6,093,700

Van-related VMT = 75 vans x 50 miles x 250 days = 937,500

Annual Net VMT Reduction = 5,156,250

At a 13.5 miles/gallon consumption rate approximated by FHWA for automobiles, and with 3M's estimate of 12 mpg for vans, the energy trade-off would be:[1]

Before: 488 cars x 50 miles x 250 days = $\frac{6{,}093{,}750 \text{ miles}}{13.5 \text{ mpg}}$ = 451,390 gallons

After : 75 vans x 50 miles x 250 days = $\frac{937{,}500 \text{ miles}}{12 \text{ mpg}}$ = 78,125 gallons

Annual Net Fuel Savings = 373,625 gallons

A comparison of total travel costs with and without vans shows the following:

Before: 6,093,750 car miles x 15¢/mile = $914,063

After : 937,000 van miles x 9¢/mile = $ 84,375

Fixed costs = 75 vans x $1560/van/yr. = 117,000

Total Van Costs = $201,375

Net Savings $712,688

$\frac{\$712{,}688}{830 \text{ riders}}$ = $859 Annual Savings per Person

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[1] In order to have comparable energy savings between vanpool programs, the authors substituted the 13.5 FHWA estimate for 3M's 15 mph figure.

This savings figure is a program-wide average with an individual's actual savings depending on the commuter's travel distance and previous mode of travel. The most significant savings would be realized by individuals with longer commuting distances and a previous pattern of driving alone. These figures include neither the $3 million that 3M stated it saved due to cancellation of a parking structure, nor the firm's administrative and financing costs of the programs. At a 1975 price of $6,440, the company has several hundred thousand dollars invested in the vans, with the principal but not the financing costs repaid out of fares; if the firm had $400,000 invested in vans, this same capital could have earned, say, 6% or $24,000 a year, which is a definite "opportunity cost."

Montgomery Ward Company[1]

Montgomery Ward's central offices are located within Chicago, a city with an extensive rail and bus transit service. However, the company's corporate headquarters with roughly 4,000 employees in January 1976, is north of the "Loop" area where many of the transit lines terminate. The company, believing that it has only fair transit access, provides ample, free parking for its employees. The incentive to investigate vanpooling came from a corporate policy to look for ways to improve the environmental and energy-related aspects of its operations, rather than from government proding or any financial constraint. After identifying a fairly strong interest among its employee population--mainly office workers and managers--and promoting the project within the firm, Montgomery Ward began a 6-van pilot project in October 1974, which by February 1976 had expanded to 14 vans and 157 passengers. Four of its routes are entirely within the City limits, while the other 10 originate in the surrounding suburbs.

The 12-passenger vans carry an average of 11.2 passengers. The driver/coordinator arrangement is similar in concept to the 3M Company system, with the driver permitted somewhat restricted use of the van during evening and weekend oeriods at a cost of 8 cents per mile. Service is handled by a local dealer, billed to the firm, and covered by fares. Back-up vans are scheduled to be purchased in case of breakdown. The firm also provides preferred parking spaces for its vans.

Following its policy on all company vehicles, Montgomery Ward leases the program's vans at an average monthly rate of $125 per van. Insurance is handled by one of the Company's subsidiaries and each van is assessed a $120 annual insurance fee. Total monthly fixed costs, including leasing and insurance expenses, average approximately $150 per van with an additional variable cost of 8 cents per mile. Each passenger pays a monthly fare equal to one-eighth of the van's allotted fixed and mileage costs, but the driver does not pay a fare and is allowed to keep the fares from any passengers over the 8 person minimum. If a van's occupancy falls below eight persons, the driver has one month to find a new passenger, but this has not been a problem. The van's round-trip mileage ranges from 30 miles ($25 fare per month) to 90 miles ($38) with the average length of a round-trip roughly 56 miles and monthly fare $30.25.

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[1] Information on the Montgomery Ward program was obtained from Forstater and Twomey, p. 39; and from conversations with the program's Director, Chuck Geserick in February 1976.

As one might expect for a firm in a central city area with a variety of transit available, it is estimated that roughly half of the vans' passengers come from mass transit. This figure would mean that the average automobile occupancy of the roughly 78 persons who formerly commuted by car was 1.63 -- well above the 1.20 average estimated for work trips to the Chicago CBD.[1] Close to half the automobile commuters, therefore, who switched to vanpools formerly rode in carpools.[2]

Using the mileage figure for the average vanpool trip, the removal of 48 cars would mean a VMT savings = 48 cars x 56 miles x 250 days = 672,000 with a net VMT savings of 476,000 and a vehicle trip reduction of 8,500 per year. Energy savings would be:*

$$\frac{672{,}000 \text{ car VMT}}{13.5 \text{ mpg}} = 49{,}778 \text{ gallons}$$

$$\frac{196{,}000 \text{ Van VMT}}{12 \text{ mpg}} = 16{,}333 \text{ gallons}$$

Net Fuel Savings = 33,445 gallons

* The van mileage figure is the same one used by 3M in their analysis and assumed to be applicable here.

Montgomery Ward does not feel that it has realized any identifiable savings, such as reduced parking needs or better on-time performance. There are, however, the secondary benefits perceived by company officials of favorable corporate relations and improved employee morale for those using the vans. Though the numbers are rather small, the loss of mass transit riders is certainly not a favorable development, even though the transit commuters who switched to vanpools probably received better service at a lower cost. Assuming that a vanpool rider formerly used one of the Chicago area's seven commuter rail lines, and the Chicago Transit Authority (CTA) for the local inner-city trip, fares for a 50-60 mile round-trip would be roughly $3 per day for the railroad and 90 cents for the bus or subway, or a total of approximately $1,000 annually without considering the costs of transportation to the train station. At slightly over $1.42 per day or $360 per year, the same commuter receives door-to-door service at a savings of at least $640--a fact well known by Chicago's transit operators, whose 1975 figures showed commuter rail operations losing $37 million while CTA lost roughly $50 million.[1] Any strong move, however, from transit to vanpools is both environmentally detrimental and a self-limiting process.

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[1] U.S. Dept. of Transportation, Urban Data Book. Report No. DOT-TSC-OST-75-45, II (November 1975).

[2] Assuming an average carpool occupancy of 2.5, a 1.63 overall occupancy rate would mean that 42 percent of the automobile commuters rode in carpools.

Tennessee Valley Authority [2]

To help reduce traffic congestion and dependence on private automobiles, TVA organized a commuter vanpool program for its 3,200 employee headquarters in downtown Knoxville, Tennessee (population 175,000) to supplement an existing express bus service. Initiated in June 1974 as a 6-12 passenger van pilot project (organized through the Authority's Credit Union due to legal complications) the fleet was further expanded in September 1975 by the addition of 6-15 passenger vans. Two travelled to Knoxville and the other 4 served satellite offices and job sites. With 5,300 employees expected at the construction site of TVA's planned nuclear power plant, the Authority intends to operate 65 vans to this location and expand bus service so that at least 40 percent of the workers can be carried by vans and buses, a neccesity due to limited highway capacity in the area.

TVA selected areas not served by transit and sent questionnaires on vanpooling to employees residing in those areas. Based on this survey information, potential drivers and riders were selected for the commuter vanpool program. Drivers' responsibilities are similar to the 3M concept, including personal use of the van at 8 cents/mile. The Credit Union leases the vans, makes all related arrangements (insurance, licenses, etc.) handles all van accounts and fare collections, and works with TVA officials on survey and operational problems. TVA subleases the vans when necessary for workday use, gives technical advice to the Credit Union which it also protects from any program-related losses.

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[1] "Chicago's Own Commuter Crisis," Business Week, (October 20, 1975), p. 51.

[2] This material is based on a discussion of the TVA program given in G. Miller and T. Green, Guidelines for the Organization of Commuter Van Programs, The Urban Institute (Washington, D.C.: 1976).

Fares are collected by either direct payment to the Union, through the van drivers, or by payroll deductions. Another novel program element is the fact that 90 percent of the van riders are "park-and-riders" who travel to selected pick-up points along the vans' routes, thereby significantly lowering their travel-time. It would tend, however, to raise the cost of commuting and be less energy-efficient and environmentally beneficial than a residential pick-up system. Yet this system does seem to appeal to riders, and without it many might choose to use their cars instead.

Surveys of the vanpool riders performed by the program's administrators produced an estimate of 5.8 cars removed per van with 42 percent of the vanpool riders formerly driving alone. The other 58 percent were former carpoolers. The 5.8 car replacement figure is below 3M's 6.5 car/van estimate because of the lower "drive alone" and higher "carpool" percentages for the former modes of vanpool users. Of the riders on the Company's 20 subscription buses, over 65 percent were formerly lone drivers, which TVA feels is due to the shorter travel range of bus riders which is up to 30 miles per round-trip versus 40-130 miles for vanpool routes. At these longer distances, automobile commuters are more likely to share rides as a way of reducing travel costs of $3,000 to $4,000 per year for the 100+ mile trips.

The operation of 12 vans out of the Knoxville office (11 into Knoxville and one "reverse commute" from Knoxville to one of the TVA dams) at 5.8 cars removed per van results in roughly 70 fewer car trips per day or 58 fewer daily vehicle trips. No average van trip length is given; but, considering the high mileage range, a figure of 70 miles would seem justifiable. This would mean an annual VMT reduction of about one million miles attributable to these vans. Energy savings would equal:

$$\text{Before: } \frac{1{,}225{,}000 \text{ Car VMT}}{13.5 \text{ mpg}} = 90{,}740 \text{ gallons}$$

$$\text{After: } \frac{210{,}000 \text{ Van VMT}}{12 \text{ mpg}} = 17{,}500 \text{ gallons}$$

Net Fuel Savings = 73,240 gallons

At the average vanpool trip distance of 70 miles, the monthly fare would be $28.66 (Fares range from $20 to $33 per month. Employee savings from the program would then be:

Before:	70 cars (140 people) with 1,225,000 VMT x $.15 mi.	= $184,000
After:	12 vans = 140 riders x $1.35/day x 250 days	= $ 48,000
	Net Employee Savings	$136,000

This total annual figure translates to almost $1,000 per year, and considerably over $3,000 if a person previously drove 100 miles alone everyday. Even employees formerly in a 3- passenger, single-car carpool at the average mileage of 70 miles would each save over $500 annually. It should be stated, however, that any automobile travel by vanpool riders in order to get to pick-up points would decrease the overall energy and VMT savings.

Conclusions

The number of significant commuter vanpool programs presently operating is relatively small and even the oldest has been in existence for less than three years. Few of these programs have collected the extensive "before versus after" travel data needed for reliable quantitative analyses. However, certain factors have emerged, and these can help us to ascertain reasons for success in various settings.

General Suitability. The vanpool can be a viable means of transportation for work trips, especially when the place of employment and the employees' residences are both located in suburbs or more distant rural locations where an increasing proportion of industrial and commercial development has occurred in recent years. An effective commuter vanpool program can provide benefits to all parties concerned. For the employer, the vanpool can provide a reliable tool for reducing the difficulties and costs associated with attracting labor into suburban or rural areas where transit service is scarce, but other operating costs are lower than in CBD locations. For the employee, the vanpool is a low-cost alternative to the private automobile and is especially cost-effective for longer trips. By reducing the daily VMT and vehicular trips needed for a firm's employees, numerous public objectives--emission reduction, energy conservation and congestion reduction -- may be served.

By its nature, the ideal setting for vanpools occurs when employee residences are "clustered" in a small number of locations so that the time required to collect ten or more employees is not excessive. Long "line haul" distances between collection areas and the plant sites are more conducive to vanpooling than shorter distances since the cost per mile decreases substantially with mileage. It is possible for vanpool users to drive to pick-up points along a van's route in order to reduce the total trip time that elapses when all passengers must be collected at their homes.

Clerical or production workers with fixed hours are able to utilize the vanpools more extensively than high-level executives with frequent travel requirements and irregular hours. At 3M Company, the ratio is 3:1 among vanpool riders. The mixture of employees in vans across the country, however, has included representatives from all levels of the salary range. In all cases, a continuing commitment by the employers to vanpools appears essential to effectively handle the basic organization of the programs, the procurement of vehicles, arrangement of the insurance, the recruitment of drivers, and the matching of riders. Numerous everyday problems require competent follow-through by a firm's administrators.

Competition With Transit. The Montgomery Ward example indicates that vanpools are capable of inducing people out of mass transit modes. A similar observation was made by Prudential's vanpool directors who, though thoroughly committed to mass transit, reported a strong interest in vanpools by employees at their CBD location in Newark. Almost all of these prospective vanpool users would be fugitives from the bus and rail lines. Because of the high load factor, the vanpool apparently is able to offer convenience, comfort, and time efficiency at a cost at or below that offered by the typical transit lines, especially the commuter railroads.

The competitive success of vanpools over transit is not automatic, however. In the case of a vanpool program organized at a Chrysler Corporation plant in Syracuse, New York, the vanpool program began with the handicap of fares inflated by high leasing and administrative costs. It was then disrupted by heavy plant layoffs and was finally dissolved when bus service was extended to the plant by the local transit authority at fares that undercut the average vanpool costs.

Rider Costs and Savings. The savings realized by employees in commuter vanpool programs depended on the type of program arrangement, the extent that the firm's costs (administrative, interest on capital) are excluded from the fare base, and the mode of transit used by the vanpoolers before the program began. Those switching from single passenger cars had the greatest savings while those switching from local transit or carpools had the least. The VMT and energy savings resulting from a program depended upon the number of people taken out of low-occupancy cars and average trip length of vanpool users. The following table summarizes the various cost/benefit factors affecting the ride.

Range of Cost/Benefit Factors Per Vanpool Rider

Fare Charged per Mile: 1.9¢ to 2.5¢/mile of total route
Travel Cost Savings : $640 to $150 annually
Gasoline Savings : 180 to 830 gallons
VMT Reduction : 3,035 to 10,830 annually
Trip Reductions : 54 to 217 annually

Employer Costs and Savings. Many employers are reluctant to discuss cost factors, and the differences in accounting systems make comparison among different employers difficult. For example, the programs are often included within the overall operations of a firm's personnel, public relations, or related offices. Very approximate estimates, however, place the range somewhere on the order of $1 to $20 per rider annually. Only the 3M Company registered any official estimate of program-related savings — a substantial $3 million for the foregone parking space construction.

APPENDIX

SECTION III

CASE STUDIES OF DEDICATED HIGH-OCCUPANCY VEHICLE LANES AND RELATED PARKING FACILITIES

Introduction

General

Over 50 planned or existing HOV lane programs have been identified by the Federal Department of Transportation, excluding lanes limited to use by emergency vehicles. All but 12 of these exclusive lanes are limited to bus use. Eight of the 12 lanes that allow carpools as well as buses have been implemented since December 1973, indicating growing support for such paratransit modes as carpools and vanpools which are proving to be important factors in local and national transportation, energy, and environmental strategies.

Urban Street and Arterial Roadway HOV Lanes

The majority of HOV lanes have been established on major arteries and streets in large and medium-sized cities. They typically consist of curb lanes reserved exclusively for express or local bus use. In rarer instances, median lanes, "contra-flow" lanes[1] and "bus only" streets are utilized for priority bus movements. Existing HOV lane systems on arteries or city streets -- thirty four are operating as of January 1976 -- range in scale from a four-block curb bus lane program in Buffalo, New York, to a twenty-six mile system of multi-vehicle-type curb lanes situated along eighteen

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[1] Contra-flow use one or more lanes from a roadway's "off-peak" direction for peak period use by vehicles heading in the opposite direction; e.g., a six lane highway would use one eastbound lane for westbound travel in the morning, and reverse the process in the evening rush hours.

TABLE IIA-1

COMPONENTS AND IMPACTS OF SELECTED EMPLOYER-BASED VANPOOL PROGRAMS

	Firm Type & Location	# Employees	# Parking Spaces Transit Service & % Using Transit	Vanpool Startup Date & # Vans	Present # Vans & Passengers	Average Van Route Mileage and Monthly Fares	ΔVMT (annual)	ΔVehicles Trips (annual)	Gasoline Consumption (annual)	Estimated Employee Savings	Estimated Employer Costs and Savings	Former Mode of Vanpool Riders
Hoffman-LaRoche	Offices & some production in Nutley, N.J., a suburban area	~6,200	4610 free spaces 3% of employees using fair to poor transit service	2/74 4 vans	20 vans 240 pass. @ 12 pass. per van	55 miles @ $26.47	-2.6 million (130,000 per van)	-52,250 (2600 per van)	-200,000 gallons	$350,000 ($1500/ rider)	~6,500/year for vanpool/carpool/ transit program. No savings figure given	HL officials assume: 100% single auto Authors: ≃88% single auto 12% other auto
3M Company	Main headquarters - largely offices but some labs - located in suburban St. Paul	7700 in 1970 ~10,000 in 1976	~7200 free lot spaces & 800 garage spaces @ $15/month (vanpools park free in preferred garage spaces)	4/73 6-12 pass. vans	75 vans ~830 pass. @ 11.1 pass. per van	50 miles @ $27.40	-5.2 million (70,000 per van)	-103,250 (~1400 per van)	-380,000 gallons	$700,000 ($850/ rider)	Substantial program expenditures (2 full time personnel + part-time engineer), but estimate $3mil. in forgone parking space construction and good publicity.	49% single auto 7% drive w/pass. 23% carpool rotaters 16% carpool riders 4% dropped off 1% transit
Montgomery Ward	Corporate Headquarters - full range of office personnel located in northern Chicago	~4000	No figure available, but stated by MW to be "ample free parking" and good transit service(no % given)	10/74 6-12 pass. vans	14 vans ~151 pass. @ 11.2 pass. per van	56 miles @ $30.60	-476,000 (34,000 per van)	-8,500 (607 per van)	-33,800 gallons	$150,000 ($640 for former transit riders, $925 for former auto travelers)	Estimate administrative cost of 15 man hours/ month - no other figures available No savings mentioned.	31% single auto rotating pool drove w/pass. 19% rider dropped off 50% transit
Tennessee Valley Authority	Authority's Headquarters in downtown Knoxville; full range of office and managerial workers	3200	No figure available	6/74 6-12 pass. vans	12 vans (6-12pass. 6-15 pass.) 140 riders @~11.6 pass. per van (13 vans at other TVA sites)	No figure given but estimate of 70 miles @ $28.66 used	-1 million (~83,000 per van)	-17,500 (1460 per van)	-73,000 gallons	$136,000 ($1000 per rider)	Most costs covered by fares, but were TVA administrative costs (surveys, publicity, etc.) but no cost or possible savings data available.	42% single auto 58% carpoolers (total drivers and riders)

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city streets in Washington, D.C.[1] Since CBD congestion is not usually confined to the peak commuting periods, almost sixty-five percent of these HOV lane programs remain operable for significant parts of days and even up to twenty-four hours. Some arterial lanes only have severe congestion problems and heavy bus traffic during morning and evening rush hours, and are only in effect during these periods.

Based on the performance of these thirty-four operating inner-city HOV lanes, including those on major arterials that are similar to freeways in most aspects, one study has devised a generalized rule-of-thumb guideline that matches priority buslane options with those factors necessary to justify their implementation.[2] A summary of the guideline is presented in Table IIIA-1.

Table IIIA-1

General Characteristics of Arterial Buslanes (Buses Only)

TYPE OF TREATMENT	PLANNING PERIOD (YR)	MINIMUM DAILY BUS VOLUME	RANGE IN ONE-WAY PEAK-HOUR VOL. BUS	PASS.	STREET CHARACTERISTICS	RELATED FACTORS
Bus streets	5–10	200	20–30	800–1,200		Commercial frontage. Part of CBD plan. Available alternative traffic routes.
CBD curb bus lanes, main street	1–5	200	20–30	800–1,200		Commercial frontage.
Curb bus lanes	1–5	300	30–40	1,200–1,600	At least 2 lanes available for other traffic in same direction.	
Median bus lanes	1–5	600	60–90	2,400–3,600	At least 2 lanes available for other traffic in same direction. Ability to separate vehicular turn conflicts from buses.	
Contra-flow bus lanes, short segments	1–5	200	20–30	800–1,200		Essential part of bus routing pattern necessary to serve generators or reduce bus miles.
Contra-flow bus lanes, extended	1–5	400	40–60	1,600–2,400	At least 2 lanes available for other traffic in opposite direction. Signal spacing greater than 500-ft intervals.	Ability to provide service.

Source: Herbert Levinson, Crosby Adams, William Hoey; Bus Use of Highways: Planning and Design Guidelines, NCHRP Report # 155, Transportation Research Board, Washington, D.C. (1975).

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[1] Such inner-city lane designations are common, especially in large central cities. Enforcement is generally nonexistent, with "moving and parking" violations greatly reducing any benefits to transit vehicles.

[2] See Table IIIA-1 for reference.

These minimum bus and rider volumes reflect aspects of both the "person-carrying" capacity of roadways and the problems of enforcing lane-related traffic regulations. The minimum peak-hour volume of 20-30 buses carrying 800-1200 passengers, represent a significant increase over the average "mixed use" lane flow of 100 to 600 person-trips per hour.[1] Forty to sixty buses per hour are needed for optimal self-enforcement of non-curb priority lanes, such lanes tending to remain genuinely exclusive only when a bus is in view consistently during the peak periods.[2]

"On-Freeway" HOV Lanes

Slightly over a third of all planned and existing HOV lanes are part of urban freeways, either through exclusive use of one or more existing lanes, special adaption of median or bordering right-of-way, and/or the metering of freeway ramps to allow preferential entrance to higher occupancy vehicles. The freeways affected by these programs are usually subject to severe congestion during morning and evening peak-periods, but generally do not have the off-peak congestion experienced on many CBD streets. The operations of these freeway lanes reflect this relationship. All but five of the eighteen on-freeway HOV lanes operate only in peak periods. In those instances where peak-period bus flow is almost exclusively one-directional, contra-flow priority lanes have been implemented for buses, with other vehicles usually excluded for safety and enforcement reasons. The relationships between peak and off-peak directional flows, and the minimum number of buses considered necessary to justify contra-flow lanes on freeways are found in Table III A-2.

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[1] Levinson, Adams, Hoey, Bus Use of Highways, p. 105.

[2] Levinson, Adams, Hoey, Bus Use of Highways, p. 105.

Table III A-2

Approximate Minimum Bus Volumes Required For Contra-Flow Bus Lane [a]

TOTAL PEAK-DIRECTION DEMAND (VEH/HR)	MINIMUM BUS VOLUME REQUIRED FOR OFF-PEAK DIRECTION VOLUME (VEH/HR) OF													
	900	1200	1500	1800	2100	2400	2700	3000	3300	3600	3900	4200	4500	
3600	34	41	90	135	205	288	365	495	693	1701	3130	5355	7594	
3900	14	22	36	54	82	115	146	198	277	680	1252	2142	3038	
4200	10	17	28	42	63	89	112	152	213	524	963	1648	2337	
4500	8	13	21	32	48	68	86	116	163	401	736	1260	1787	I[b]
4800	5	9	14	22	33	46	58	79	111	272	501	857	1215	
5100	4	6	10	15	23	32	41	55	77	189	342	595	844	
5400	2	3	5	8	12	17	22	30	42	102	187	320	454	
6300	1	1	2	3	4	6	8	11	15	37	68	117	166	
7200	1	1	1	2	3	4	5	6	9	23	42	72	103	II[b]
8100	—	—	—	1	1	2	2	4	5	13	23	40	57	
						III[b]								

[a] Assumes an occupancy factor of 1.5 and 50 for automobiles and buses, respectively.

[b] I—These bus volumes exceed most urban bus fleets and fall outside the domain of practical application.
II—The domain of practical application—involves hourly bus volumes ranging from about 40 to 200.
III—Volumes of under 40 buses per hour do not usually warrant contra-flow lanes.

Source: See Table III A-1.

Other freeway preferential programs are not as inherently restrictive about the type of HOV that can utilize the priority lanes. In fact, nine of the fifteen noncontra-flow freeway HOV lane programs give preferential treatment to both buses and carpool vehicles. In all but two instances, carpools are defined as cars with three or more passengers. The Shirley Highway project maintains a four-passenger minimum, while two-passenger vehicles are given preferential treatment at metered entrances to the Hollywood Freeway in Los Angeles. The latter is one of eight planned or operating freeway projects throughout the country that have ramp systems allowing carpools and buses to bypass other traffic when entering freeways. In addition, separately constructed, exclusive ramp entrances provide HOVs a direct access to preferential lanes on four existing freeway HOVL projects — Shirley Highway, I-495 in New Jersey, the San Bernardino Busway, and the new I-95 lanes in Miami. Other exclusive entrances or preferential ramp systems simply lead designated vehicles onto mixed-flow highways. The overall characteristics of freeway-related bus lanes are summarized in Table IIIA-3 (see next page).

HOV Lane Funding

The majority of planned and existing HOV lane projects are funded solely from state and local resources. However, funding assistance from the Federal level will frequently be used for freeway projects. Only six percent of the street and arterial programs received some federal funding, while over forty percent of all freeway-related projects were in part federally funded.[1]

Parking Facilities for Carpool and Bus Riders

Many freeway and arterial HOV lane projects have included policies to provide parking facilities in suburban areas which act as (a) "staging areas" to which auto users can drive and form carpools, and as (b) "park-and-ride" facilities for car drivers to leave their cars and switch to express buses. The carpools and buses can then enter the HOV lanes for the remaining portion of the trip into the CBD. Such facilities allow high-occupancy modes to handle the line-haul portion of these trips, while passenger collection and distribution in the morning and evening can be handled by private automobiles.

In a number of cities, including Seattle and Miami, special carpool lots are provided in downtown CBD areas as an inducement to carpooling. Occasionally, downtown spaces are also offered at reduced prices to carpoolers to further increase the economic incentives of ride-sharing.

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[1] Transportation Systems Center, Priority Techniques for High Occupancy Vehicles, U.S. Department of Transportation, Cambridge, Massachusetts, (November, 1975).

Table III A-3

General Characteristics of Freeway-Related Buslanes (Buses Only)

TYPE OF TREATMENT	PLANNING PERIOD (YR)	DESIGN YEAR[a] RANGE IN ONE-WAY PEAK-HOUR: EXPRESS BUS VOLUME	DESIGN YEAR[a] RANGE IN ONE-WAY PEAK-HOUR: BUS PASSENGER VOLUME	DESIRED AVERAGE PEAK-HOUR BUS TIME SAVINGS (MIN/BUS)	TOTAL PEAK-HOUR USER TIME SAVINGS[b]	OTHER RELEVANT CONDITIONS
1. Busway:						
(A) Special right-of-way	10–20	40–60	1,600–2,400	5	Positive[c]	Direct penetration of non-freeway corridor. Special access to or distribution within centers. Stations required. Within CBD, bus speeds under 6 MPH; and/or CBD over one square mile in area.
(B) Freeway median	10–20	40–60	1,600–2,400	3	Positive[c]	Freeway congested, ramp metering insufficient. Contra-flow lane not feasible, stations required.
(C) Railroad right-of-way	10 10	20–30 40–60	800–1,200 1,600–2,400	3–5 2–3	Positive[c]	Existing unused railroad grade available. Urban development related to discontinued rail service. Interim use of right-of-way acquired for rail transit. Stations required. Direct penetration of nonfreeway corridor.
2. Reserved freeway lane:						
(A) Normal flow	5	60–90	2,400–3,600	5	Positive	Freeway congested, ramp metering insufficient. Queue bypass lane upstream from bottleneck. Corridor level of service for other vehicles reasonable. Required to meet environmental or air pollution standards.
(B) Contra flow	5	40–60	1,600–2,400	2–3	Positive[c]	Freeway congested, ramp metering insufficient. Unbalanced flow permits reversing lane attaining level of service D in off-peak directions. Intermediate stops not required. Freeways, six or more lanes with no left-hand access.
3. Other:						
(A) Toll plaza bypass	5 5	15–20 20–30	400–600 600–800	5 2–3	Positive	Toll barrier meters highway, good operation downstream. Adequate reservoir area on approach to toll station.
(B) Exclusive ramp to mixed-traffic lanes	5 5	10–20 5–10	400–600 200–400	2 3	Positive	Mixed-traffic lane has good operating conditions.
(C) Metered freeway ramp with bus bypass lane	5	10–15	400–600	1	Positive	Alternate surface route available for metered traffic. Express buses leave freeway to make intermediate stops.
(D) Bus stops on freeways	5	5–10[d]	—	5	Positive	Convenient pedestrian access to stop. Stops on ramps result in undue delay. Minimum passenger use 50 per hour. Generally provide at surface level in conjunction with metered ramps.

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[a] Base year should represent at least 75 percent of design year.
[b] Bus passenger time savings plus bus operator cost savings plus savings (or minus delays) to other road users, relative to "do nothing" alternative.
[c] Normally other users experience time savings when buses are removed from traffic stream.
[d] Stopping, not counting through express buses.
[e] Minutes per boarding passenger.

Source: Herbert Levinson, Crosby Adams, William Hoey, Bus Use of Highways: Planning and Design Guidelines, NCHRP Report # 155, Transportation Research Board, Washington, D.C. (1975).

Examples of HOV Lane Projects: City Street and Arterial Roadways

South Dixie Highway (Miami, Florida)[1]

The South Dixie Highway is the main arterial link between central Miami and suburban Dade County, a rapidly growing residential area of over 200,000 persons situated south of the city limits. The highway, a regional section of U.S. 1, is a four-to-six lane facility which cuts across thirteen miles of the suburban South Dade region and is punctuated by signalled intersections. It then extends five-and-a-half miles into central Miami. Over 70,000 vehicles use the South Dixie Highway daily, a large proportion utilizing it during peak periods as the main roadway in that corridor. Before the HOV lane was implemented in late July 1974, the evening peak-period vehicle counts on the heavily traveled 5.5-mile northern segment of the highway ranged from 14,700 in February to 16,000 in July.[2] Carpools comprised 75 percent and 19 percent respectively of those trips. However, since project officials defined carpools as vehicles with two or more passengers, average vehicle was still only 1.38 in February and 1.25 in July. Pre-project bus traffic volume on this segment was insignificant with only five express runs carrying 360 passengers during each perk-period in June 1974 -- less that two percent of the daily peak-period person-trips carried on the highway.

The region's desire to reduce the heavy traffic congestion on this highway was increased by rising fuel prices and vehicle operating costs as well as deteriorating air quality. To alleviate these problems, the South Dixie Highway Transportation Improvement Demonstration Project was implemented in late July, 1974. The project was planned, implemented, and financed by state and local government agencies, principally the Florida Department of Transportation and Metropolitan Dade County.

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[1] Information on South Dixie Highway obtained from Metropolitan Dade County, U.S.1/South Dixie Highway Transportation Demonstration Project Evaluation Report (November 1975); Harry Rose and David Hinds, "U.S.1/South Dixie Highway Contraflow Buslane and Carpool Lane Demonstration Project," unpublished paper (January 1976); and conversations with Harry Rose in March 1976.

[2] Project officials based many of the before and after results of the HOV lane program on separate February and July comparisons, because of differences in travel behavior during winter and summer months. Winter vehicle counts normally increase due to tourist influx and decrease in the summer as more work trip commuters are on vacation. The figures above appear to be the inverse of this assumption, but this is regarded as a short-term driver reaction in February to the energy crisis. Also, although morning peak period counts are unavailable, project officials claim that they more than mirror the evening figures.

The main component of the project was an HOVL facility along the highway's heavily traveled northern segment into Miami. Two existing lanes carrying mixed flow traffic gained preferential status during the peak morning and afternoon hours (7-9 AM and 4-6 PM). One lane was contra-flow, separated from the opposing flow of traffic by removable posts, and carrying only buses. Access to and egress from the lane was limited to two points along the highway with buses leaving and entering the with-flow speed lane nearest the median divider. Along this with-flow speed lane, carpools were given exclusive right of way. An original plan to physically separate this carpool lane from the other with-flow lanes was later abandoned because of safety reasons, and is presently separated by special line designations and sign posts, allowing two-passenger carpools free access to the lane anywhere along the HOVLs 5.5-mile length. In order to insure both the safe operations of the lanes and improvement of the freeway's "through-put" volume flow along all lanes, a number of traffic improvements and restrictions were imposed:

1) Elimination of left hand turns at intersections by South Dixie vehicles, while providing right hand loops onto cross-streets as alternatives.

2) Increasing the "green time" of traffic signals along the South Dixie Highway by thirty seconds per intersection, as well as improved synchronization of signals. Both were implemented along the entire 18 1/2 mile stretch from central Miami through suburban South Dixie.

To increase transit ridership along the corridor, Dade County's Metropolitan Transit Agency increased the number of existing express bus routes between South Dade and Miami from one to six, while also increasing the number of daily peak-period runs from ten to eighty-four (later reduced to sixty-one). Average fares remained

Table III A-4

Project Budget

U.S. 1/South Dixie Demonstration Project

BUDGET ITEMS (S)	CAPITAL COST	OPERATING COST	FLORIDA-DOT COST	DADE COST	TOTAL COST
Manufacture/purchase, Install all signing, posts and related hardware for lane restrictions	$ 270,281	$ -	$ 135,140	$ 135,140	$ 270,281
Install bus shelters and signs	60,800	-	10,150	50,650	60,800
Transit Operation Deficit	-	407,488	218,257	189,231	407,488
Placing and Maint. of delineators and maint. of bus shelters	-	198,395	97,948	100,447	198,395
Enforcement	-	63,648	33,134	30,514	63,648
Signal Equipment purchase, adjustment and installation, additional paving	119,100	-	59,550	59,550	119,100
Project Coordinator, contra-flow manager, Operational Improvement manager and Planning manager	-	58,650	29,325	29,325	58,650
Advertising Promotion	-	35,850	24,543	11,307	38,850

Table III A-4
(continued)

BUDGET ITEMS (S)	CAPITAL COST	OPERATING COST	FLORIDA-DOT COST	DADE COST	TOTAL COST
Safety Attenuators	$ 60,000	$ -	$ 30,000	$ 30,000	$ 60,000
Parking Lot Improvements	116,000	-	58,000	58,000	116,000
Evaluation		32,500	17,125	15,375	32,500
TOTAL			$713,612	$711,000	$1,424,612
10% Contingency			71,361	71,100	142,461
Total Project			784,973	782,100	1,567,073
Total Capital			322,619	367,170	689,789
Total Operating			462,354	414,930	877,284

the same, at a little over fifty cents. Having entered central Miami, express buses feed into a new bus terminal, where transfers to all other city routes can be made. In order to further increase commuter access to express bus routes and encourage carpool development, five fringe parking facilities were designated as park-and-ride stations. In addition, a 160 space parking lot for carpools (two persons or more) was established in downtown Miami with rates set 40 percent below the average cost of commercial downtown parking spaces.

Project costs for the first year of the project are found in Table IIIA-4 (see preceding page),along with the sources of program funding. Since July 1975, the project costs have been paid entirely by Metropolitan Dade County.

Impacts

The separation of traffic, limitations on turns, and improved signaling on the South Dixie Highway produced the following changes in travel time over the affected corridor. The effects of reduced vehicular use on travel time has been accounted for by creating an artificial "original configuration," which indicates what post-project passenger levels would be if traveling under pre-project vehicular and road conditions and mode splits.

Table IIIA-5

Travel-Time Changes Along 5.5-Mile Project Corridor

	Bus lane	Carpool lane	General lanes
Travel Time Difference For Vehicles Using Project Lane Structure and Original Configuration	Saved 10 to 19 minutes	Saved 2 to 6 minutes	Lost 1.3 to 3.25 minutes

Dollar cost savings, using average hourly wage levels for bus and carpool passengers as a scale, were computed by project officials to exceed $2.6 million annually.[1] Additional cost savings were realized from reductions in out-of-pocket costs, as indicated in Table IIIA-6.

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[1] Average hourly wage rates obtained from user surveys were $7.65 for bus users, and $10.50 for carpoolers. Total bus lane savings were 39 man-hours/day saved x $7.65; carpool lane savings were 966 man-hours/day saved x $10.65. Total daily savings were $10,441, or about $2.6 million annually.

Table IIIA-6

Out-of-Pocket Cost Savings

Category	Daily Savings	Annual Savings
Auto operating * (11.3¢/mile used)	$3,913	$978,250
Parking * (40¢/day used)	534	133,500
Transit fares * (52.5¢/trip used)	-784	-196,000
	$3,663	$915,750

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* Automobile operating figures were estimated by Florida DOT for Dade county in April 1974. Parking charge is an average of survey results. Transit fare figure is an average of current South Dixie routes.

The positive effects of the project on vehicular use can be seen in the fact that vehicular travel was reduced slightly even though peak-period person trips increased by almost 2400. Table IIIA-7 summarizes the changes.

Table IIIA-7

Project Effect on Vehicular Use and Person Trips During the P.M. Peak Period

	Immediate Results			Long Range Results		
	July '74	Aug '74		Feb '74	Feb '75	
Vehicles	16,000	14,420	-10%	14,700	14,330	- 2%
Person Trips	20,000	20,700	+ 4%	20,250	22,640	+12%
Average Vehicle Occupancy	1.25	1.45	+16%	1.38	1.6	+14%

The reduction of vehicular travel was directly influenced by increased use of bus and carpool lanes. Bus ridership grew from about 360 when the project began to 1300 only one week later. By January 1976, the ridership had exceeded 2,000 daily. Survey results of express bus users indicated that almost two thirds of the riders formerly drove alone, eleven percent came from carpool vehicles, and the remaining twenty-three percent were former express and local bus users along this and other corridors.

Based on these and other survey results, the program has resulted in the following reductions in trips, VMT and fuel consumption:

Table IIIA-8

Impact of Dixie H'wy. HOV Lane on VMT and Energy

	Change Daily Car trips 1/	Change VMT on Lane Segmt. 2/	Change in VMT-Total Commute Distance 3/	Change in Tot.Trip VMT (Annual)	Annual Energy Savings(gallons) 4/
Carpool Effect	-2550	- 28,050	-72,420	-18.1mill.	-1.34mill.
Express Bus Effect	- 580	- 12,760	-14,152	- 3.5 "	-0.26 "
Total HOV Effect	-3710	-40,810	-86,430	-21.6mill.	-1.60mill.

1/9000 afternoon carpoolers x 61% switching from single pass. auto÷2.16 carpool occupancy = 2550. 1000 afternoon bus riders x 66% from single pass. auto x .89 daily useage = 580.

2/11 mile round trip on HOV lane. Effect of 51 additional bus runs on VMT reduction is insignificant

3/28.4 miles average round trip for carpoolers; 24.4 mile figure used for bus riders; both figures based on survey data.

4/Assumes 13.5 mpg.

Passenger Characteristics. Survey results of lane users showed that higher income groups still prefer the private automobile, although they appear moderately willing to use carpooling. The median income levels of bus riders, general lane users and carpoolers were roughly $11,000, $16,250 and $21,800 respectively, with over 58 percent of the carpoolers falling into the "$20,000 and over" income bracket.

The trip purpose of the overwhelming majority of the highway's users was the home-work commuter trip, although the percentage drops from 95 for bus riders to 88 for carpoolers, and to 83 for other auto users. As many as 13 percent of person-trips recorded during the afternoon peak in the general lanes were for such non-work trip purposes as shopping, recreation, and personal business.

Parking Utilization. Approximately 50 percent of the express bus ridership utilized the five park-and-ride lots; and 10 percent of the parkers surveyed in one of these lots were using the facility as a carpool staging area. Although the CBD carpool lot was utilized by 200 cars daily, this figure represents only a fraction of the total number of carpool vehicles. Roughly 42 percent of the CBD-bound carpoolers parked in regular commercial garages or lots, while another 34 percent parked in employee provided lots.

Accidents and Lane Violation. The number of accidents along the five-and-a-half mile project length of the South Dixie Highway increased by 45 percent during the first year of the program. The largest increases were rear end collisions (up 63 percent), sideswipes (up 65 percent) and right-turn related accidents (up 400 percent over the previous year's total, but still accounting for only six percent of the entire year's accidents). In other words, the number of accidents per million vehicle miles almost doubled from 6.4 to 12. The number of accidents involving buses totaled 36, over two-thirds of these caused by illegal left-hand turns into the contra-flow lane. After nine months new safety cones prevented reoccurences of this type of accident; and, in general, bus-related accidents decreased after six months. The percentage of carpool lane violations was kept below a daily average of 10 percent, primarily due to lane surveillance by 18 police officers.

Business Impacts. Before the project's implementation, businessmen along the South Dixie Highway voiced fears that left turn restrictions would reduce sales volumes of nearby establishments due to the restriction of automobile access. Enlisting the aid of the Greater Miami Chamber of Commerce, a controlled sample of various types businesses in the affected corridor and elsewhere were questioned about changes in retail sales over the first nine months of the project. Overall, nearby business firms reported better business sales than during the previous year. Firms elsewhere also reported a rise, and only one firm listed any component of the HOV lane project as affecting sales volume in any manner.

York Road/Greenmount Avenue (Baltimore, Maryland)[1]

York Road/Greenmount Avenue and Forest Street/Hillen Street form a major commuting corridor between the Baltimore CBD and the major outlying residential area of Towson about 5.6 miles to the north. It is one of 13 commuter corridors between suburban areas and Baltimore identified by Region III of US/EPA in December 1973 as prime sites for the establishment of exclusive bus/carpool lanes. Section 52.1108(b) of the Baltimore Metropolitan Region Transportation Control Strategies required the designation of "with-flow" preferential treatment lanes during morning (6:30 to 9:30 AM) and evening (3:30 to 6:30 PM) peak periods from Monday through Saturday, along major arteries in these corridors, with each lane averaging approximately six miles in length.

Local officials, primarily the Mayor of Baltimore, were successful in attempts to have EPA amend the order to allow experimental implementation of bus priority lanes, only on a more limited scale. (Although the EPA order was directed at the State, it is the city which has legal power over all its highways). In May of 1974, administrators from the Maryland Mass Transit Administration and Baltimore officials from the (a) Departments of Transit and Traffic, Planning, and (b) the Mayor's office, selected for an initial buslane pilot project the York Road/Greenmount Avenue corridor, as this arterial already had: 1) numerous express and local bus routes with relatively high ridership levels, and low headways, 2) on-route parking restrictions, and 3) the lack of such external congestion factors as construction or poor road design.

The project began on the four-lane roadway in July 1974, when the curb in the peak flow direction was designated for exclusive use by local and express buses, with other vehicles allowed to use it when making right turns. The lanes were set up during specified two-hour periods of peak traffic congestion.

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[1] Information on York Road bus lane was obtained from City of Baltimore Department of Transit and Traffic, State of Maryland Department of Transit Administration, Exclusive Bus Lane Study (April 1975); and conversations with John Erdman, Assistant Commissioner of Baltimore DOTT, in March 1976.

Since the project was experimental and implemented to test changes in traffic flow, not in modal splits or corresponding changes in VMT, no funds were provided for bus service upgrading, lane widening, or signal improvement. In fact, efforts were made to remove all "uncontrollable influences" from the corridor so the pure effects of the priority curb lane could be measured. Enforcement of the lanes by Baltimore police was fairly limited, with no increase in assigned police personnel over the pre-project level. The only major component of the program, besides the official lane designation, was the evaluative effort to measure travel speed and delay information.

Results of the experimental corridor project, presented in terms of travel time changes, are described in Table III-9.

Table III-9

Change in Auto and Bus Travel Times Due To The Exclusive Bus Lane

	Summer Schedule		Winter Schedule	
	AM	PM	AM	PM
Auto Travel Time	+1.83%	+6.31%	+8.81%	+7.48%
Bus Travel Time	+10.65%	+5.49%	-9.45%	+3.07%

Source: City of Baltimore Dept.of Transit and Traffic, State of Maryland Dept.of Transit Administration, Exclusive Bus Lane Study: Preliminary Report (January 1975).

The fact that seven out of eight situations showed an increase in travel time points out the serious problems of a bus lane of this nature. With both express and local buses operating in one lane, faster buses had to break into the regular traffic lane to pass. This was often difficult and led to travel delays for express buses, while limiting the other traffic to one lane caused problems for those vehicles.

According to project officials, "no significant divergence from automobile to bus usage can be expected as a result of the exclusive bus lanes."[1] Indeed, random ridership counts showed no appreciable changes after project implementation. Further, it became obvious to evaluators "that the imposition of exclusive bus lanes upon routes, such as the one servicing Towson, does not improve transit operation and will ultimately increase emissions."[2] The major arterials in the other thirteen commuter corridors in the region resembled the Baltimore-Towson case along at least a portion of their route, and project officials recommended other alternative strategies to reduce commuter vehicular use. Nonetheless, the York Road/Greenmount Avenue project is still in operation, although no new travel time computations or ridership counts have been undertaken since November 1974.

Examples of HOV Lane Projects: On-Highway Exclusive Roadways

General

A number of high-occupancy vehicle lanes, including (a) the Shirley Highway Bus/Carpool Lane in northern Virginia, (b) the special bus lanes on the approaches to the Lincoln and Midtown tunnels into Manhattan, (c) the I-93 bus/carpool lane in northern Boston, and (d) the San Bernardino Freeway Express Buslane in Los Angeles. have been established in urban areas recently. Established in the 1971-1974 period, these lanes ran through "bottlenecks" where daily congestion delays were significant and, therefore, where exclusive lanes could provide buses or carpools a sufficient time advantage to induce greater use of these modes.

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[1] City of Baltimore Department of Transit and Traffic, State of Maryland Dept. at Transit Administration, Exclusive Buslane Study: Preliminary Report,(January, 1975), p. 28.

[2] Baltimore Department of Transit and Traffic, Exclusive Buslane Study: Preliminary Report, p. 29.

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Shirley Highway in Virginia

The Shirley Highway Buslane between the suburbs of Virginia and Washington, D.C. is a permanently constructed busway that is physically separated from the rest of the highway. It opened in 1969 with a five-mile section of two peak-period reversible lanes. The length has subsequently been extended to 12 miles under the joint auspices of federal, state, regional and municipal governments. In addition to the roadway, the project included new bus routes, buses, designated park-and-ride areas, and bus shelters. Buses average 17.5 minute time savings on the lane, or a 51% reduction in line-haul time compared to a 26 percent decrease in overall total trip-time. Bus patronage exceeded 14,000 in 1975, a growth of more than 150 percent since 1969. Ridership suffered a drop in December 1973 when four-person carpools were allowed to use the lane. Almost 25 percent of the 5000 carpoolers using the lane formerly rode Shirley Highway express buses.

Long Island Expressway (I-495 in New York)[1]

The Long Island Expressway contra-flow buslane extends 2.2 miles in Queens to the Midtown Tunnel river crossing into Manhattan. Since its establishment in 1971, it has operated during morning peak hours, providing almost 10 minutes of line-haul savings to nearly 10,000 daily riders. No park-and-ride facilities are specifically provided for bus passengers, and financial support of the relatively low-cost lane by public agencies has not been extensive.

The I-495 Approach in New Jersey[2]

The Lincoln Tunnel exclusive buslane was opened to traffic in December 1970 as probably the most publicized and heavily used of all contra-flow reserved buslanes on a major freeway. It runs for 2.5 miles from the junction of three highways to the entrance of the Lincoln Tunnel at the Hudson River. The contra-flow pattern is used from 7 AM to 10 AM on weekdays, and park-and-ride lots are available near the beginning of the lane and at strategic points on feeder expressways. Public response to the bus service has been enthusiastic, and about 44,000 daily passengers were using it in January 1976.

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[1] Information obtained from Crowell, W., Gerrard, M., and Sewell, G., Social, Economic, and Environmental Impacts of Selected Transportation Strategies, Final Report (September 1975).

[2] Information obtained from Crowell, et al, and from conversation with Carl Selinger of the Port Authority of New York and New Jersey, May 1976.

The I-93 Bus/Carpool Lane in Boston

This with-flow lane, opened in two stages during 1974 to a final length of 1.4 miles, is located in the lower level of the two-level bridge in Charleston. One lane out of four is designated for carpools (3 or more passengers) and buses for the 6:30 to 9:30 AM period on weekdays. The lane has reduced travel time for these modes by 38 percent over the 1.4 miles, and it was used by roughly 500 carpools and 32 buses in mid-1975.

The San Bernardino Freeway Express Busway

The San Bernardino or El Monte Busway is a physically separated, permanently constructed 11-mile busway facility providing buses with a bidirectional, exclusive right-of-way and off-line stations where about 2,000 park-and-ride spaces are provided. Completed in stages over the 1973-75 period, the busway's three stations and associated parking facilities were operational by the end of 1975. In the combined five-and-one-half hours of morning and evening peak periods, the number of bus passengers has increased from 1,000 before the busway to around 10,500 in March 1976. Concurrently, an estimated 5,500 "potential" cars were removed from peak-period traffic, reducing daily VMT by 77,000.

Users of the Lanes

Four of these five examples of exclusive lanes (San Bernardino excepted) operate in rush hour periods only. Only one (Shirley Highway) operates both in the morning and evening peak periods. Rush hour periods are dominated by work trips; and working commuters, therefore, make up the large majority of the lane users. Most of the travelers by car or express bus are coming from suburban areas and have relatively high incomes. Data from interviews of Shirley Highway users,[1] and an express bus survey in Queens,[2] New York, showed that express bus riders' incomes were significantly above the median income level for the particular travel corridor. This tendency was partially due to the higher fares on express buses compared to other available local transit, but it was also a result of the relatively comfortable, convenient buses serving an upper-income suburban population.

Benefits of the Lanes to Users

The principal benefit of an exclusive lane is time savings for the preferred vehicles, and significant travel time reductions were calculated in every example. Shirley Highway figures show the "line-haul" and total trip time of buses was reduced by 51 percent and 26 percent respectively with an average savings of roughly 18 minutes over the "no lane" option.[3] The "contra-flow" lane on the approach to the Midtown Tunnel saved expresses buses from 4 to 20 minutes during the 7:30 to 9:30 AM period, and Boston's I-93 cut 4.5 minutes off the travel time of buses and carpools over its 1.4 miles. The point, however, that must be remembered, especially in the express bus examples, is that even though an exclusive lane may provide time savings, the total travel time of the carpoolers and bus riders is usually greater than the main competitor — the single passenger automobile. Approximately 87 percent of San Bernardino Busway passengers, for example, had their overall travel time increase when they switched from single passenger cars to transit.[4] Travelers who formerly drove alone mention monetary savings as the dominant reason for switching to transit or paratransit modes. Such convenience and comfort factors as park-and-ride lots and express bus service within walking distance of residence and work locations are also considered important. The time savings afforded by an HOVL are viewed as one of a number of "service improvements" that are effective in increasing the use of transit and paratransit modes.[1]

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[1] UMTA, Shirley Highway Express Bus-On-Freeway Demonstration Project: Final Report (September 1975).

[2] Polytechnic Institute of New York, Survey of Ridership/Express Buses in the City of New York (1974).

[3] UMTA, Shirley Highway: Second Year Report (1973).

[4] Bigelow-Crain Associates, p. 54.

The extent of monetary savings varies considerably with trip length, the cost of alternative modes, and the parking and toll expenses that are "city specific." Table IIIA-10 describes time and travel cost savings for three of the exclusive lanes presented here:

Table IIIA-10

Summary of Time and Travel Cost Effects

		Bus Lane		
		Shirley Highway	Long Island Expressway	I-495
1.	Average time saved	11 miles 17.5 minutes	2.2 miles 9.5 minutes	2.5 miles 7.75 minutes
2.	Total time saved (rush hour)	4100 hrs./day	1500 hrs./day	5700 hrs./day
3.	Average number of bus riders (rush hours)	14,000	10,000	44,100
4.	Representative Bus travel costs 2/	$1.50/day	$3/day	$3.50/day 1/
5.	Representative Automobile travel costs	$5/day	$8-$11/day	$9-$10.25/day
6.	Representative daily cost savings of bus	$3.50/day	$5-$8/day	$5.50-$6.75/day

1/ Based on $2.60 sample fare and $1.00 per day local transit that most bus travelers from New Jersey require. Auto costs assume 15 mile travel distance, the May 1975 commuter (non-carpool) discount toll rate of $1 per day, and the same parking rates as for the L.I.E. XBL. However, there are no toll-free bridge crossings from New Jersey.

2/ The major cost difference is due to public operation of Shirley Highway buses (therefore lower fares) and free transfers for express bus passengers onto local METRO buses.

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[1] See rider survey results in Bigelow Crain Associates, p. 66; UMTA, Tables 21 and 27; Polytechnic Institute, p. 45.

The savings identified in Table IIIA-10 are substantial, particularly compared to the total costs of a 30-mile, round trip by automobile, which also can include up to $4.50 in daily CBD parking costs (New York City). In the recent analysis of the San Bernardino busway, where low base fares and commuter discounts mean an average fare of only 10 cents on routes using the busway lane, average per-trip savings for busway users ranged from minus $.35 to positive $1.94, with the negative savings a result of switching from a carpool with free CBD parking to being dropped off at the bus station and riding by bus into the CBD.[1] In the case of the Long Island Expressway lane, survey results indicate that most express bus users increase their travel costs and time by switching from their previous mode, because the dominant previous mode was the subway system with average fares ($1/day) and travel time often less than the bus could offer. The balancing factors are the increased comfort, convenience, and safety provided by express buses over the subway alternative.[2]

Impact of the Lanes on Vehicle Trips and VMT

As only two of the five examples shown here allow carpools and buses on them, the main impact occurs in the area of increased bus patronage. It is difficult to apportion a specific percentage of the changes in "modal split" to the existence of the exclusive lane as numerous exogenous and endogenous factors also play important roles in everyday modal decisions. The energy crisis of 1973-74, at the time some of these lanes opened, made automobile use even more difficult by significantly raising gasoline prices which widened the gap between automobile and transit travel costs. Express bus service in (a) other areas of New York City not served by any special lanes, and (b) Knoxville, Tennessee and other cities without any lanes, have experienced patronage increases similar to those in HOVL corridors. Rider surveys show that substantial fare reductions and the provision of park-and-ride facilities were influential components of ridership gains in the San Bernardino Busway program.[1]

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[1] Bigelow-Crain Associates, San Bernardino Freeway Express Busway Evaluation: Second Year Report. Prepared for Southern California Association of Governments (September 1975), p. 52.

[2] Polytechnic Institute (1974), p. 45.

Despite these limitations, some statements can be made on the lane's effectiveness in inducing greater use of carpools and buses and less use of single passenger cars. The following Table IIIA-11 shows how a number of lanes affected automobile and bus travel. Bus travel increased by relatively small amounts where substantial bus commutation already existed, such as from New Jersey into Manhattan via I-495. On the other hand, large increases occurred where bus commutation and express service was a relatively new experience, as in the Los Angeles area. Though all of the programs reported either no significant change or an increase in automobile travel on their respective highways, the crucial point is what the total trips and VMT would have been without the special lanes and the related bus services.

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[1] Bigelow-Crain Associates, p. 66.

TABLE IIIA-11
Bus and Automobile Traffic Before vs. After HOV Lane

HOV Lane Projects		BUS TRAFFIC			BUS PASSENGERS			Autos	Change in Auto Occupancy
		Before Lane	1975	% Change	Before Lane	1975	% Change	% Change	
I-495	Peak Hour	483[4]	550	+ 14.0	21,252	24,730	+16[1]	+10[7]	n.a.
	Peak Period	826	1050	+ 27.0	34,692	44,100	+27.0		
Shirley H'wy	Peak Hour								1.35 to 1.65
	Peak Period	109[6]	282	+158[5]	5,400[3]	13,957[3]	+158	+65	
Long Is. Exp'way	Peak Hour	79	114	+44	3,801	5,485	+44[2]	n.a.	n.a.
	Peak Period	158	230	+44	6,646	9,675	+44		
I-93 Boston	Peak Hour								1.35 to 1.44
	Peak Period	15	32	+113	480	1,024	+113	+ 9.3	
San Bernardino Busway	Peak Hour[8]								
	Peak Period	55	229	+316	1,000	10,000	+900	"no significant change"	"no significant change"

[1] Percent change in ridership is greater than of buses because of an increase in the number of passengers per bus.

[2] Assumes no change in peak hour and peak period riders per bus on both express and airport buses.

[3] Estimate of June 1975 figure based on October 1974 figure of 13,706 and the average 1972-74 growth rate.

[4] January-April 1971 average.

[5] Based on average 1969-74 bus occupancy of 49.7 (to balance out large month to month variations).

[6] March 1971.

[7] Based on Port Authority Vehicle counts.

n.a. = not available.

[8] Peak period = total AM and PM peak hours of 5.5

With this factor in mind, the analysts of the Shirley Highway and San Bernardino exclusive lanes have estimated that the following trip and VMT reductions can be attributed to these lanes:

Table IIIA-12
Examples of VMT and Energy Consumption Changes
Due to HOV On-Freeway Lanes

	Cars Diverted by Busway	Net Daily VMT 1/ Savings	Change in Daily Energy Consumption
San Bernardino (5.5 peak hours) ((only))	5,500	77,000	-66,000 gal. gasoline +1,000 gal. diesel oil
Shirley Highway (AM peak period)	7,600	186,000	-17,166 gal. gasoline

1/ San Bernardino example has "cars diverted" divided into (a) leave car home (b) park-and-ride, and (c) kiss-and-ride. It also compensates for use of the car when it is left home. These adjustments result in a VMT reduction/car removed of 14 *versus* 25 for the Shirley Highway.

Costs of On-Freeway Exclusive Lane Operations

The following Table outlines the capital and operating costs of a number of the exclusive lanes studied:

Table IIIA-13
Capital and Operating Costs of
HOV On-Freeway Lanes

	Total Costs of Construction	Annual Operating Costs
Shirley Highway	$42.4 mill.	$ 10,000
I-495 Lincoln Tunnel	2,042,500 1/	200,000 1/
L.I.E. Midtown Tunnel	44,100	107,500
San Bernardino Busway	57 mill.	165,000 2/

1/ Includes expenses for signal system and TV surveillance within the tunnel that are used by cars and buses.
2/ Annual cost of maintaining stations only.

The exceptionally large expense for the totally separated busways in Los Angeles and Washington, D.C. are in sharp contrast to the relatively inexpensive operations in New York City. The bulk of the operating expenses for the I-495 and the Midtown tunnel are the labor-intensive costs for the daily set-up of the contra-flow lanes.

Conclusions

The examples of on-highway preferential treatment of buses and carpools analyzed here are notable for their wide variety of scope and impact on vehicular travel and costs. The HOVLs into the Lincoln and Midtown Tunnels in New York City and on I-93 in Boston are "highway management" programs that attempt to increase the passenger carrying capacity of already heavily congested facilities. The two busway examples in Los Angeles and Washington, D.C. involved the construction of completely new roadway lanes within an existing right-of-way. All of the projects cited increased their car-carrying capacity as shown in the related increases in automobile use. Bus travel was made more attractive; so were the highways' overall facilities. Although the VMT and trip figures, when compared with real or projected "without lane" estimates, show energy savings and emission reductions, the actual level of travel on the highways has increased. Additional problems were created in the Midtown Tunnel, where express bus service attracted former subway riders and, therefore, caused an increase in VMT and emissions.[1]

The HOV lane on the Dixie Highway in Miami was more successful than the "on-arterial" project in Baltimore because of (a) the total approach used in Miami, including greatly expanded express bus service, signalization improvement, turn prohibitions, and newly constructed "turn-outs", (b) the limitation of the bus lane to express buses only, and (c) the South Dixie Highway being a 6-lane roadway with mixed traffic on two lanes in both directions. The arterials selected in Baltimore were only 4-lane roads, had no special traffic signal phasing, and had a mixture of local and express buses that resulted in delay-causing lane changes. The key factor for success is that the project in Miami has turned the arterial highway almost exclusively into a commuter corridor with all lane assignments and traffic signals heavily favoring the CBD-bound traffic.

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[1] Polytechnic (1974), p. 43.

Both highway and arterial HOV lanes offer definite time savings to preferred vehicles, although total travel time is reduced far less than is the line haul portion of the trip. Park-and-ride facilities are helpful in increasing bus patronage, but they entail (a) the continued ownership, availability, and use of a car with its associated costs, and (b) the time-consuming "mode switch" to buses that commuters are often reluctant to make. The major deciding factor seems to be the total cost of the alternative modes, with high parking costs, tolls, and gasoline prices acting as inducements for transit and paratransit use. In summary, HOV lanes are not a panacea for traffic congestion and related air pollution and energy problems. However, a significant change in personal travel patterns, especially for the CBD work-trips can be expected when applied in combination with other factors, such as good overall bus service, lower fares, high automobile commutation costs, employer-based carpool incentives.

TABLE IIIA-14 COMPONENTS AND IMPACTS OF SELECTED HIGH-OCCUPANCY-VEHICLE LANE PROGRAMS

				PROJECT EFFECTS					
Project and Geographical Setting	Project Description	PARTICIPANTS: Planning Implementing Financing	Implementing & Operating Costs	Travel Time Changes	Trip Purposes and Rider Characteristics	Passenger Modal Shifts	Change in Vehicle Occupancy and/or Change in Ridership	Change in Vehicular Use	Change in Annual VMT
CITY STREET/ ARTERIAL July 1974 So. Dixie H'wy -links Miami, Fla. with suburban south Dade, 5.5 mi. south; pop. 210,000 -4 to 6 lanes, signaled intersections -70,000 daily vehicles -16,000 PM peak	1)Bus contra-flow and 2-passenger carpool with flow lanes. Operational with peak direction flows. 2)Left turn restrictions. 3)Traffic flow improvements. 4)Expand express bus coverage by 600%. 5)Designate 5 fringe parking lots, and 1 CBD carpool lot. 6)Increased police surveillance.	State DOT Local -Metropolitan Dade County -4 police forces -Chamber of Commerce	Implementation $.69 million Operating $.87 million ~50/50 split between State and Metro. Dade County	Bus Lane -10 to -19 min. 50% to 60% Savings in line haul time. Carpool Lane -2 to -6 min. 13% to 30% Savings in line haul time. General Lanes +1.3 to +3.25 min. 7% to 20% Loss in line haul time. Total trip Bus total trip time reduced 17%	Bus Lane 95% worktrip Med. income $15,000 Carpool lane 88% worktrip Med. income $21,000 General Lane 83% worktrip Mean income $16,000	Bus Riders 66% single occupancy 11% carpoolers 23% transit Carpoolers 61% single occupancy 27% carpoolers 5.5% transit	V'cle Occup. Increase ~15% from 1.25-1.38 to 1.45-1.6 Carpool vehicle occupancy 2.16 Bus Riders 350 daily, pre-project >2,000 daily, 1 year later Carpool Riders Approximately 5,000 new carpoolers	The number of auto vehicles fell by between 2% and 10%, depending on base periods chosen. At same time number of passengers increased by between 4% and 12%.	Reduction of 21.6 million mi. for total trips Reduction of 8.5 million mi. along 5.5 mi. corridor: 16% reduction
July 1974 York Rd./Greenmount Av. -Links Baltimore CBD to Towson suburban area, 5½ miles north. -Narrow road corridor, with no major peak congestion problems -12 to 20 local and express buses per peak hour.	1)Experimental exclusive bus lane along curb during peak hours. Allow Express and local buses, right turning autos, and autos avoiding left lane delays, or turns. 2)Limited police surveillance 3)All other factors kept same; project objective to measure travel time change for bus and autos, due only to exclusive lane designation.	State Maryland Mass Transit Administration Local -Dept. Transit & Traffic -Dept. Planning -Mayor Federal Region III EPA ordered experiment.	Costs of lane designation & project evaluation indeterminable by project officials. All costs incurred for lane designation, however, would have been City financed.	Bus Travel Time on Lane Average increase of 2.4% Auto Travel Time on Non-profit Lanes Average increase of 6.1%	Trip Purpose Peak period work trips.	Did not seek this information.	No change in bus ridership noticed from limited bus counts.	No change noticed.	No Change.
FREEWAY RELATED Feb. 1974 I-93 -Links Boston to northern suburbs -2 tier structure with southbound 4 lanes underneath in Charlestown -2-hour AM peak of 5,115 total vehicles; 560 carpools; 31 buses.	1)Left lane bus and 3-passenger carpools exclusively for 1.4 miles on southbound tier in Charlestown. 2)Operates 6:30AM-9:30AM 3)Third lane became barrier separation 4)Preferentially treated traffic given head of line advantage at lane's end. 5)Enforced by expelling violators from I-93, increasing travel time up to 20 min.	State -Dept. of Public Works -State Police	Implementation $35,000 Operating Nominal to DPW, but State Police incur real and/or opportunity costs directly related to time spent at enforcement.	On normal day, saving of 4.5 min. to users. 38% savings over general lanes. Up to 20 min. travel time loss to penalized violators.	Trip purpose Peak period home to work trips primarily	No data.	Vehicle Occup. Aver. increased by 6% -- from 1.35 to 1.44. Bus Riders ~1,000 riders on 32 buses. No information if this represents an increased ridership figure	Total vehicle use increased during 2-hour AM peak by 500 cars, an increase of 10%	No data.

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TABLE IIIA-14 COMPONENTS AND IMPACTS OF SELECTED HIGH-OCCUPANCY-VEHICLE LANE PROGRAMS

				PROJECT EFFECTS					
Project and Geographical Setting	Project Description	PARTICIPANTS: Planning Implementing Financing	Implementing & Operating Costs	Travel Time Changes	Trip Purposes and Rider Characteristics	Passenger Modal Shifts	Change in Vehicle Occupancy and/or Change in Ridership	Change in Vehicular Use	Change in Annual VMT
May 1971 Southeast Exp'way -Links Boston to southern suburbs -3 lanes each direction -used daily by 105,000 vehicles -10,000 vehicles northbound during AM peak -57 buses during AM peak.	1)8.4 mile contra-flow bus lane. 2)Original AM and PM operation, became AM only in 1972 -- 6:30AM to 9:30AM 3)Operated April thru October only. 4)Ended in 1976. To be replaced by withflow bus/carpool lane in the indefinite future.	State -Dept.of Public Works -MBTA during initial planing (no MBTA buses use lane)	Implementation $40,000 Operating $135,540 ann	Buslane time -14 min. Withflowlanes -4.5 min.	Trip purpose Peak period home to work trips primarily	Possible shifts of some person-trips to new competing rapid transit link. No data on shifts, if any to buses.	Vehicle occupancy declined from 1.48 to 1.43 Number of buses utilizing S.E. Exp'y increased by 14% but no information if these are new bus runs, or old switching routes	Vehicular use remained constant	No data.
Oct. 1971 Long Island Expressway -Links Queens and L.I. suburbs to Midtown Tunnel & Manhattan. -3 lanes each direction -3,800 auto v'cles enter Tunnel during AM peak hour. -158 buses use L.I.E. during AM peak periods.	1)Contra-flow express bus lane for 2.2 miles before entering tunnel from Queens. 2)Operates 7AM-9AM.	Local -N.Y.C. Transportation Adm.	Implementation $44,000 Operating $150,000 ann'ly	Buses save average of 9 minutes on lane, or 33% reduction in line haul time. Total bus travel time reduced by only 19%.	Bus Rider Trip Purpose 97.7% work .9% school Average income of bus riders is $17,640, some 28% more than aver.income of areas served by express buses.	90% of bus riders are former users of other transit. 5.5% auto drivers 2.6% were auto passengers.	Number of both express buses and riders increased by 44% (230 buses carrying 10,000 riders) No data on change in auto occupancy.	No data.	No data.

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TABLE IIIA-14 COMPONENTS AND IMPACTS OF SELECTED HIGH-OCCUPANCY-VEHICLE LANE PROGRAMS

				PROJECT EFFECTS					
Project and Geographical Setting	Project Description	PARTICIPANTS: Planning Implementing Financing	Implementing & Operating Costs	Travel Time Changes	Trip Purposes and Rider Characteristics	Passenger Modal Shifts	Change in Vehicle Occupancy and/or Change in Ridership	Change in Vehicular Use	Change in Annual VMT
Sept. 1969 Shirley H'way -Links Virginia suburbs to Washington, D.C. -3 lanes each direction -34,000 daily auto vehicles -109 buses during peak period.	1)From 1969 to 1975: 11 mi. built of 2 right-of-way lanes. Opened to buses and in Dec. 1973, to 4-person carpools. 2)Lanes reversable during 6AM-9AM and 4PM-7PM operating hours. 3)"Mixing Bowl" extension onto Washington streets. 4)90 new buses purchased for express service. 5)3 finge lots designated.	Federal FHWA, UMTA Regional WMATA WASHCOG State Va.Dept. of H'ways & Transp. Local -N.Va. Transp. Commission -D.C.Dept.of H'ways & Traffic	Implemention $43 million, + $4 million for buses. Operating $10,000 ann'ly exclusive of bus operations. $6.7 million ann'ly for bus operations.	Average savings of 17.5 minutes on lane, or 51% time reduction. Total bus trip time reduced only 26%.	Peak period work-trips served primarily. Mean income of bus users $16,000. Similar for carpoolers.	Bus Riders For riders previously making this trip: 55% single auto users 5% other auto. Carpoolers 25% former bus users.	Average auto-occupancy increased from 1.35 to 1.65, 22% increase. +175% buses +196% bus riders Total:16,000 +33% increase in carpoolers Total: 4,600	+65%	VMT reduction of 46.5 milli miles.
Jan. 1973 San Bernardino Freeway -Links eastern suburbs to Los Angeles. -4 lanes each direction -30,000 vehicles use freeway during peak periods.	1)2 exclusive bus lanes; one each direction, built on RR right-of-way for 11.2 mi. No lanes removed from freeway. 2)24-hour operation. 3)Eastern bus terminal built; 2 on line stations, and 1 ramp entrance along busway. 4)1,400 park & ride spaces at bus terminal; 4 fringe lots designated elsewhere.	Federal FHWA, UMTA Regional SCRTD, SCAG State CALTRANS Local -City of L.A. -City of El Monte Other -Southern Pacific RR.	Implementation $57 million Operating Not available. Federal gov't provided 84% of implementation costs.	Bus lanes reduce line haul trip time by 13%. But 87% riders increase total trip time 3 to 30% by using buses rather than autos. Only 13% reduce trip time on buses, some by as much as 25%.	Trip purpose Peak periods: 92% work Aver. income of bus riders $17,500 Main reason for using busway are, lower costs. Aver. savings of $1.00 per trip.	Bus Riders 50% single auto drivers 13% drive with passengers. 11% auto passengers 10% other transit	No effect on auto occupancy(1.24) Total bus ridership +700%, total:14,590. Total peak period bus ridership +900%, total: 19,090	No significant change.	VMT reduction of 19.3 milli miles.

TABLE IIIA-14 COMPONENTS AND IMPACTS OF SELECTED HIGH-OCCUPANCY-VEHICLE LANE PROGRAMS

				PROJECT EFFECTS					
Project and Geographical Setting	Project Description	PARTICIPANTS: Planning Implementing Financing	Implementing & Operating Costs	Travel Time Changes	Trip Purposes and Rider Characteristics	Passenger Modal Shifts	Change in Vehicle Occupancy and/or Change in Ridership	Change in Vehicular Use	Change in Annual VMT
December 1970 I-495 Approach to Lincoln Tunnel -Links New Jersey suburbs to Manhattan CBD -3-lanes each direction -2,300 passenger cars eastbound during AM peak hour -483 buses and 21,000 passengers eastbound during AM peak period	1)2.5-mile contraflow bus lane between N.J. Turnpike and Lincoln Tunnel 2)Lane operates 7AM-10AM eastbound to New York City 3)Buses enter lane off Turnpike via separate ramp 4)Instituted a park-'n-ride lot near Turnpike entrance	State N.J.DOT N.J. Turnpike Auth. Regional -Tri-State Regional Planning Comm. -Port Authority of NY/NJ (operator of lane and tunnel.	Initial Implementation $634,000 Capital Construction $1.4 million Operating $200,000/year Port Authority bore implementation costs NJ/DOT (2/3) and Port Auth.(1/3) shared operating costs	Bus Lane Saving of 7.75 min. on lane Total time 54% of bus riders surveyed felt lane saved 10-19 min. on total trip	Primarily work-trips.	Ridership pre-mode split: 81% continuing patrons 9% from other buses 4% auto 3% rail 3% did not make trip	Bus traffic increased 27% to 1,050 during peak period. Ridership also increased 27% to 44,100	Automobile use increased by 10%	No data.
March 1976 Santa Monica Freeway* -Links Harbor F'way and San Diego F'way in City of Los Angeles -4-lanes each direction -6AM-10AM: 28,600 vehicles east; 24,450 west -3PM-7PM: 27,650 vehicles east; 28,250 west	1)12.6 miles of with-flow bus and carpool lane in each direction. Use existing left-hand lanes 2)Both lanes operate 6AM-10AM and 3PM-7PM 3)3 person carpool minimum	Federal UMTA State CALTRANS Regional SCAG SCRTD Local -County of L.A. -City of L.A. -County of San Bernardino	Implementation $70,000 Evaluation Grant $800,000 (from UMTA) Operating Costs Not available	Non-preferential Lane Users Total travel time increased by 17% Freeway Entrance Ramps Wait time increased by 28% to 5.8 min.	Primarily work-trips	Not available	In April 1976: Total vehicle occupancy(buses & autos)in AM increased from 1.12 to 1.26. Carpools increased by 144%. Bus riders increased by 186%.	In April 1976: Total AM highway vehicles:86.5% of pre-lane count. Total AM highway passengers: 97.4% of pre-lane count. Total AM HOVL vehicles: 18% of pre-lane count Total AM HOVL passengers: 81% of pre-lane count.	Not availab

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* Discussed in detail in the separate report on City Studies.

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